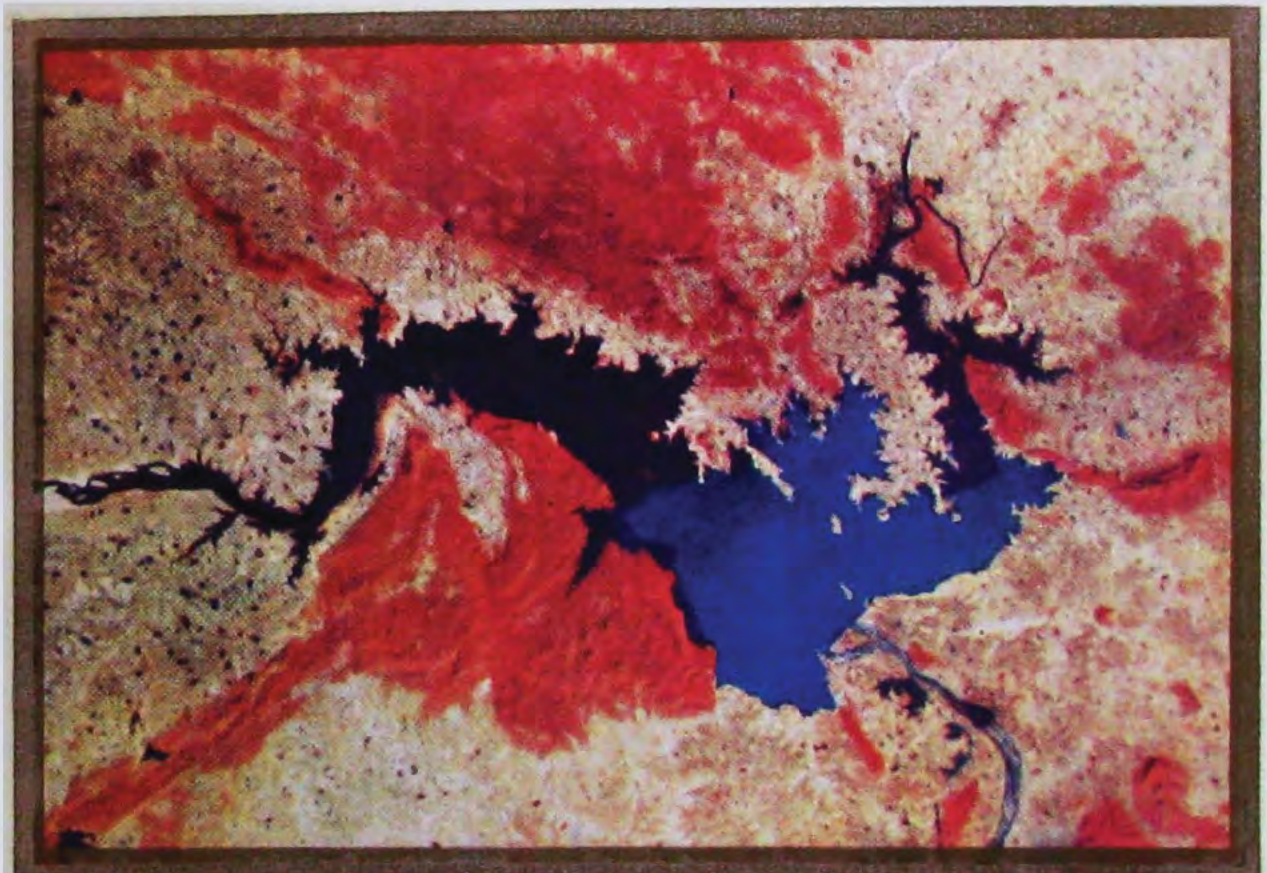
STATE OF ENVIRONMENT IN ORISSA - I

WATER RESOURCES



R. C. DAS

STATE OF ENVIRONMENT IN ORISSA

WATER RESOURCES

Dr. R. C. DAS

STATE PREVENTION AND CONTROL OF POLLUTION BOARD, ORISSA

Editorial Board for the Preparation of the State of Environment Report for Orissa

Cover Picture : Satellite image of Hirakud Dam reservoir.

Cover design by Shri C. R. Nayak, Research Analyst, S.P.C.P. Board, Bhubaneswar.

AUTHOR'S NOTE

I never realised the difficulties of preparing this report at the time of accepting the offer from the State Government in the Department of Science, Technology and Environment. Incredible it may seem, but it is true that many vital informations about our natural resources, including water resources, are lacking in the Government Departments — at least in a consolidated manner. In many cases, the data available in the files of different departments of the Government are different. We had therefore no choice but to use our "best judgement" in choosing the correct data. The sources of information have always been quoted and therefore, the responsibility of authenticity lies with the sources.

I am aware that some of my statements will generate controversy. In fact, they are intended to be so. One really cannot escape from controversy if he wants to project a truthful report of the present status of our already degraded environment. An environmentalist is still considered as obstructionist in some quarters. I hope this report will put a word of caution in the ears of our scientists, engineers and administrators — the so-called "experts", who propagate the theme of rapid and unhindered "development" as panacea to all our problems. Development without sustainability will be counter-productive in the long run.

Apart from the other members of the Editorial Board, I am grateful to Prof. N. Mahalik of the Utkal University, Shri J. Tripathy, Retired Chief Engineer, Government of Orissa and Shri G. N. Mohapatra, Visiting Fellow, Viswa Varati University who have helped me a great deal in preparing this report. Their expert opinions were invaluable.

(R. C. Das)

EDITORIAL

The Department of Science, Technology and Environment, Government of Orissa entrusted the State Prevention & Control of Pollution Board, Orissa, the task of preparing a comprehensive report on the State of Environment of Orissa. The report would cover the following four components at the first instance: (i) Water resources (ii) Atmosphere/Air (iii) Industrial and mining scene and (iv) Energy scene of Orissa. In this connection, the State Board decided to hold a series of one-day symposia on each of these subjects in which experts from various Government and non-Government departments would be invited to present papers on their respective areas of specialisation to generate enough information for the preparation of the status report.

In this context, a symposium on the "Environmental Aspects of Water Resources' of Orissa'' was organised and most of the information contained in the present report owe their origin to the proceedings of this symposium held on 30th July, 1981. This report on the water resources of Orissa purports to reflect the present status on the subject. It is hoped that the report will be a useful guideline for the future planners and policy makers of Water Resource Projects.

The content and style of the report may look somewhat unconventional In fact, it has been consciously made so, even at the risk of generating a certain degree of controversy. It was felt that with a traditional government report, one hardly gets to know and feel the relatively lesser known but equally important side of our various development projects. It is however not intended to undermine the benefits; Only that they are already too well-known. ***The views expressed in the report are exclusively of the author's and are not necessarily the official views of the State Government or the State Prevention & Control of Pollution Board.***

Besides the three permanent members of the Editorial Board for the entire project, it was thought appropriate to co-opt an expert for a particular component. Shri A. B. Jena, Retired Chief Engineer (Irrigation), Government of Orissa was kind enough to act as an expert member of the Editorial Board for the present report.

We are grateful to Shri R C. Samal, IAS., Secretary to the Government of Orissa, Department of Science, Technology & Environment not only for rendering all the necessary help but also to approve and encourage the style of the report This is indeed a rare gesture on the part of a career bureaucrat.

—Editors

INTRODUCTION

Life, as it is commonly understood, first appeared billions of years ago on this earth in water in the form of unicellular organisms from which more complex organisms evolved Some of these complex organisms gradually moved to the shores and then to firmer lands in the process of evolution. But all of them need water for existence. Man is one of those land-based and water- requiring creatures No wonder, most of its earlier settlements were on river valleys. The importance of water has been aptly described by Gothe in the following lines.

"Everything originated in water
Everything sustained by water"

Unique Properties of Water. Water is thus a very important substance which shapes, conditions and moderates the environment for sustenance of life Interestingly most of its properties, which are unique and apparently "peculiar" are designed by Nature to support life and maintain the environment That it is a liquid at ordinary temperatures and exists on the surface of this earth in all the three states of matter, viz, solid, liquid and vapour (the only substance to do so) are scientifically peculiar but have immense biological and environmental importance. Other properties like lower density of ice than water, density maximum of water at 4°C rather than at 0°C, high heat capacity, high heats of fusion and vapourisation, high surface tension, high dielectric constant, extensive hydration, slight dissociation etc are of great environmental significance.

The Hydrosphere. Out of the 1.45×10^9 km^3 of water present in the total hydrosphere of the earth, about 94% belong to the oceans and are saline. Of the ground water, only the portion in the exchangable region may be fresh and the rest saline. Thus the fresh water reserve constitutes not more than 2% of the total, out of which a good proportion is locked up in glaciers, polar ice caps, atmospheric moisture etc. In fact, ***the amount of fresh water that man is actually capable of using is only about 0.3% of the hydrosphere.*** The importance of preservation of this water, both in quantity and quality, need not be emphasised.

Table I

Composition of the Hydrosphere [1]

Source	Volume (in thousand cubic kilometres)	Percentage of the Total Volume
Oceans	1,370,323	93.93
Underground water (total)	60,000	4.12
of which groundwater in zones of active exchange	4,000	0.27
Glaciers and polar ice caps	24,000	1.65
Lakes	230	0.016
Soil moisture	83	0.005
Atmospheric vapour	14	0.001
Rivers	1.2	0.0001
Total	1,454,651	100

The Hydrologic Cycle. The water in different parts of the hydrosphere are linked by the hydrologic cycle (Fig 1). Water evaporating from ocean surfaces and lands enter the atmosphere as water vapour and then finally condense as rain and snow A part of the rain and melted snow seeps into the soil to recharge the groundwater or remain as soil moisture The rest flow as surface runoff through streams and rivers which finally reach the seas or lakes and some dry up on the way The rivers also get recharged by the groundwater reservoir. This essentially constitutes Nature's great hydrologic cycle; the main motive forces of this cycle are thermal energy and gravitation Although the total quantity of water in the hydrosphere is very large, the annual turnover of water in this constitutes only a very small fraction— about 4000 times less than the total water.

Man's use of water resources is closely and constantly linked with the operation of Nature's hydrologic cycle Although water is not removed from the cycle because of human use, man's interference can cause transfer of water from one arc or chord of the cycle to the other This causes imbalance in the existing water resources and affects the delicate balance of life. A disrupted water cycle can turn water from an abundant and renewable source into a vanishing commodity According to some experts, the recent droughts in India in 1987 are more due to bad water management and intereference with the hydrologic cycle.

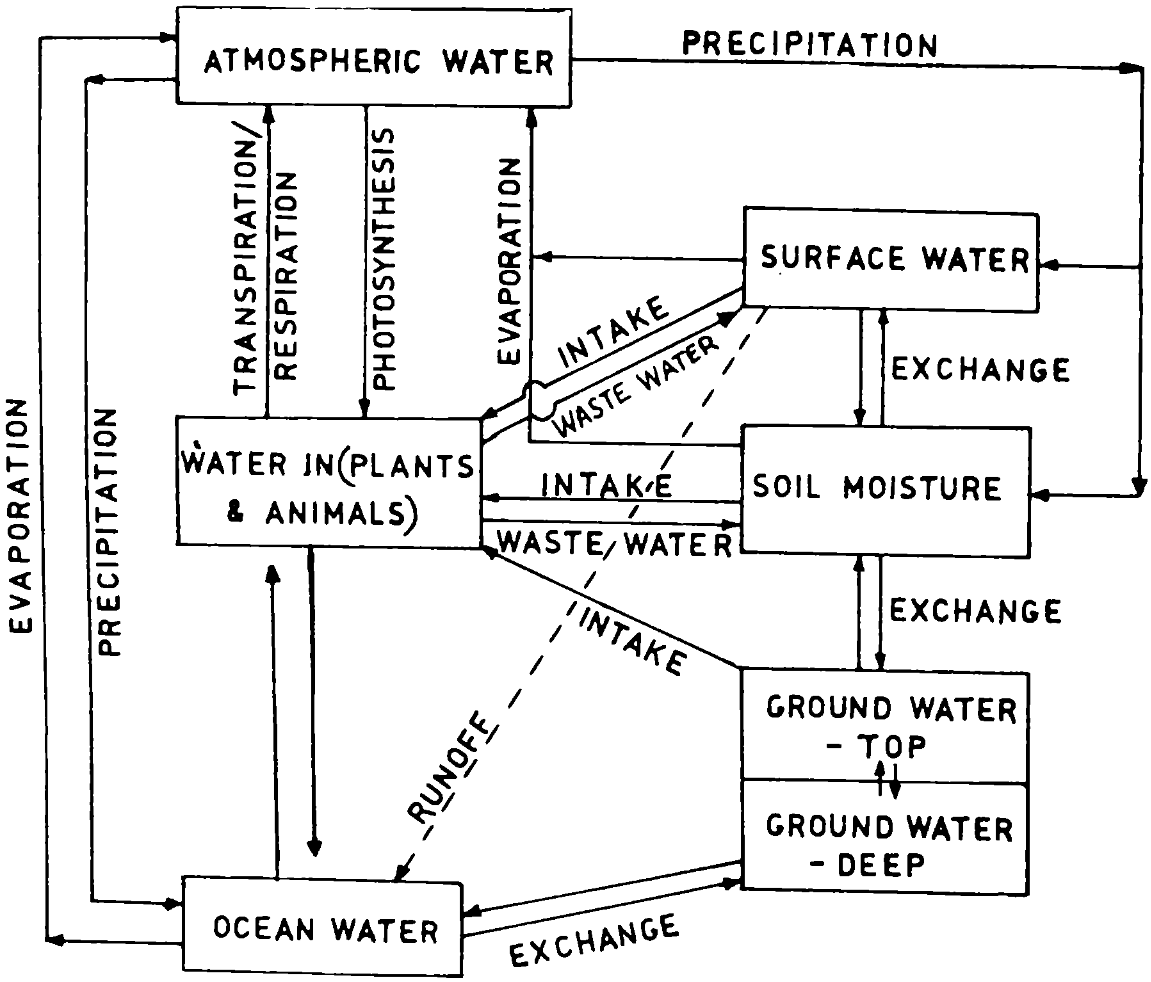


Fig-1 The Hydrologic Cycle

WATER WEALTH OF ORISSA

The state of Orissa receives an annual average rainfall of about 1.49m although it varies to some extent from district to district and from year to year depending upon the intensity of the monsoon

The annual volume of water available from rainfall over the geographical area of 15 6 Mha* is therefore about 23.19Mham*. This is the principal water resource of the state It has been estimated that, about 10 55Mham volume of water out of the above, flow through the river systems.This volume is further supplemented by water from the catchment or rivers lying outside the state. Thus the total average annual runoff through the rivers of Orissa that drains into the sea or goes to other states is of the order of 17 44 Mham. After allowing for evapotranspiration, the annually restorable groundwater potential is estimated to be 2 33 Mham. Thus the water resource of the state available for exploitation is 10 55 Mham from surface streams plus 2.33 Mham from groundwater making up a total of about 12.83 Mham The whole of it is not utilisable. Surface flow originating in the coastal plain cannot possibly be retained for utilisation. Similarly inter-state agreement has put limits to utilisation of waterflow in inter-state rivers. As per the draft Master Plan prepared by the Government, only about 7 84 Mham of water of the surface flow can be taken as utilisable water resources.

* M = million ha = hectare m = metre 1 ham = $10^4 m^3$

Table 2

Water Budget of Orissa in Comparison with India £

Sl. No.	Item	Orissa	India	Percentage of National Figure
1.	Geographical area (Mha)	15 57	329	4.73
2.	Population in 1981 (M)	26.4	685	3 86
3.	Annual rainfall (m)	1.49	1.22	122.10
4.	Annual volume of rainfall (Mham)	23 19	400 +10 (snowfall)	5.80
5.	Annual river flow as surface runoff and through groundwater aquifers and springs (Mham)	10 55	160	6 59
6.	Annual river flow from outside state catchment (Mham)	6.88	20 (from outside the country)	—
7.	Total annual river flow to sea or to outside the state (Mham) (5+6)	17 44	180	9 69
8.	Restorable groundwater after evapotranspiration per annum (Mham)	2.33	42 3	5.52
9.	Total surface water available annually for exploitation (Mham) (same as 5)	10 55	160	6.59
10.	Total groundwater annually restorable for exploitation (Mham) (same as 8)	2.33*	42.3	5 52
11.	Total annually exploitable ground and surface water (Mham) (9+10)	12 88	202.3	6.33
12.	Total annually utilisable water resources from surface flow	7 84 (as per draft master plan)	71.3 (as per draft master plan)	10.99

£ All data are very approximate figures. Data for Orissa are for 1988 obtained from WALMI (ref *3*). Data for India are for the year 1974 (ref *10*). Unfortunately, it is observed that informations obtained from different sources — mostly from Government departments — vary considerably. Thus we have used our "best judgement" in choosing the data.

* This figure is taken from the Groundwater Estimate Committee of the Government of India (ref *2*). The figure obtained from WALMI is 3.24 Mham.

Table 2 shows Orissa's water budget in comparison to that of India. With less than 5% of the country's geographical area and supporting a population less than 4%, Orissa is fortunate in water resources. The total precipitation is about 5.9% of the country, but most of it is not harnessed and go to the sea unutilised. As can be seen in the table, the surface runoff in the rivers of Orissa contributed from their catchment lying inside the state is about 10.55 Mham out of which about 7.84 Mham has been assumed as available for flow irrigation as per the draft master plan of the Government of Orissa [4]. ***This works out to be about 11% of the utilisable water flow in the country.*** In addition to this the annual restorable groundwater potential in the state is roughly estimated as 2.33 Mham.

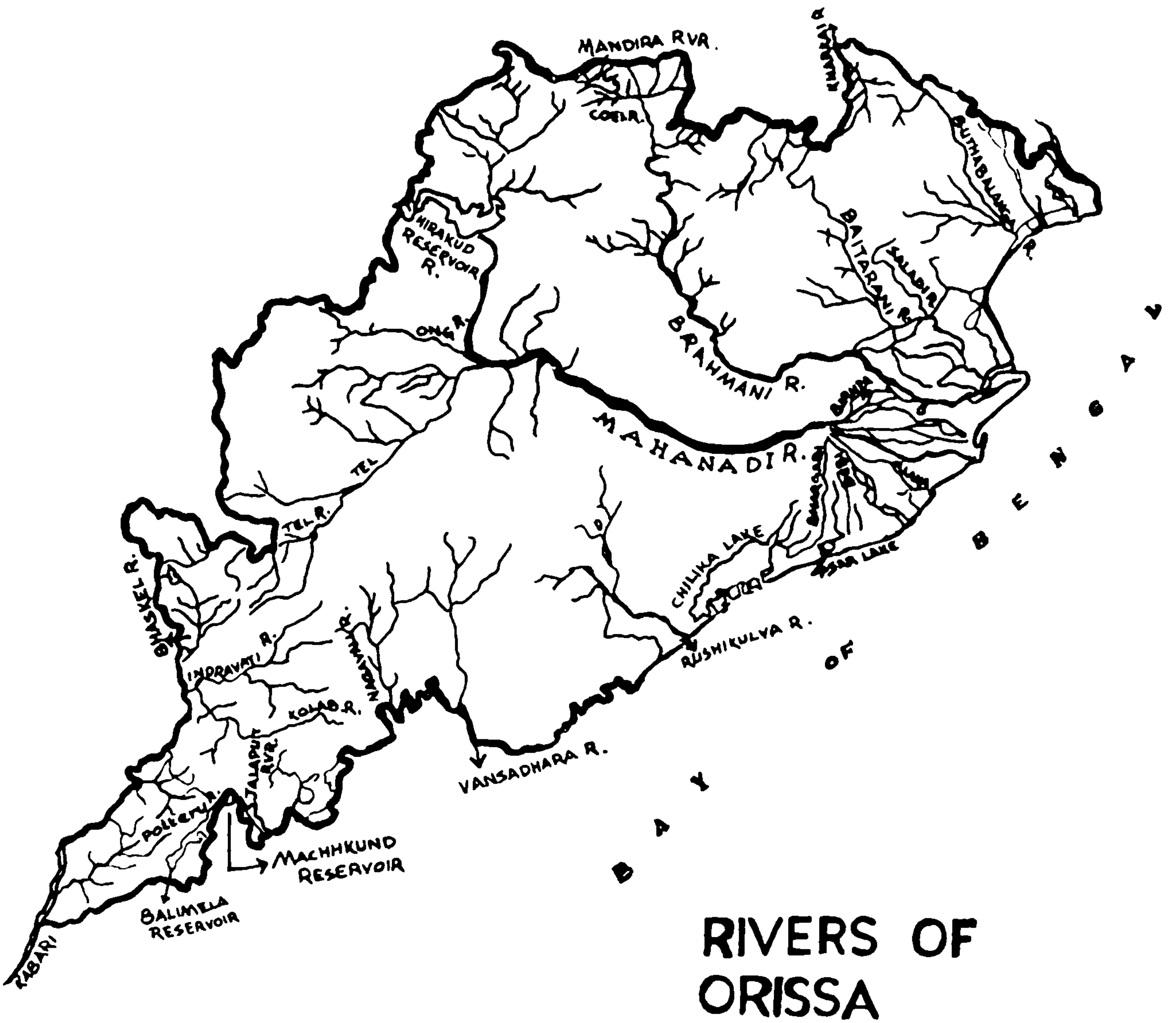


Fig-2—The Major Rivers of Orissa.

Against the quantity of 7 84 Mham of annually utilisable surface water, only 1.23Mham is presently utilised for irrigation [4]. Water needs for industries, mines, thermal power stations etc. are estimated to be about 0.1Mham. Besides, the annual water use for urban water supply is about 0.025Mham. The total annual water use therefore adds upto about 1.35Mham. This is certainly a poor utilisation of water resources in the state.

Table 3 gives the important characteristics of the major rivers of Orissa.

IRRIGATION — BOON AND BANE

The maximum use of water in this country and in Orissa is for irrigation This is necessary because of the uneven distribution of rainfall. Since almost all rains occur during monsoon months, the non-monsoon periods are practically dry. Even the rainfall in monsoon is erratic and there are evidences to suggest that it is becoming more so in recent years.

TABLE 3

Some Important Information about Major Rivers of Orissa [5].

Name of the River	Origin	Drainage Area in Km^2	Length of the Main Drainage Channel in Km	Peak Discharge in Cumecs	Annual Flow in Mm^3	Main Tributaries
Mahanadi	Parsiya in Raipur district of Madhya Pradesh	1,41,600 (65,579 in Orissa)	851 (494 in Orissa)	44,740 (43,654)	66,640 (51,061)	Seonath, Hasdeo, Mand, Ib, Jonk, Ong & Tel
Bramhani	Nagri village in Ranchi district of Bihar	39,033 (22,248 in Orissa)	800	22,640 (22,654 at head of Delta)	18,810 (at Janapur 18,311)	Karo, Sankha, Tikira, Singada, Sankoi & Chilanti
Baitarani	Ganasika village in Keonjhar district	12,789	365	14,150 (14,158 at head of Delta)	5,755 (5,452 at Akhuapada)	Arredi, Siri, Salandi, Kusai, Kukurkata, Tel, Kanihari, Gohira & Remal
Subarnarekha	Chotnagpur Plateau of Ranchi district of Bihar	19,300 (2,123 in Orissa)	395	17,000 (16,990)	7,940 (7,941 at Rajghat)	Kanchi, Karkari & Khadkei
Budhabalanga	Similipal hills of Mayurbhanj district	4,837 (4,847)	164	5,660	2,177 (637 at Kuliana)	Sore, Gangahar, Palpala & Katra
Rusikulya	Daringbari area of Phulbani district	7,753	146	8,495	1,800 (1,762)	Padma, Badanadi, Gadahada & Bhaguva
Bansadhara	Belelaged village of Phulbani	10,800 (8,015 in Orissa)	221	4,700 (4,701)	3,500 (3,460)	Paladi, Gangudi, Sananai, Paddagodda, Dhamni and Chudaldhua

Against the quantity of 7 84 Mham of annually utilisable surface water, only 1.23Mham is presently utilised for irrigation *[4]*. Water needs for industries, mines, thermal power stations etc. are estimated to be about 0.1Mham. Besides, the annual water use for urban water supply is about 0.025Mham. The total annual water use therefore adds upto about 1.35Mham. This is certainly a poor utilisation of water resources in the state.

Table 3 gives the important characteristics of the major rivers of Orissa.

IRRIGATION — BOON AND BANE

The maximum use of water in this country and in Orissa is for irrigation This is necessary because of the uneven distribution of rainfall. Since almost all rains occur during monsoon months, the non-monsoon periods are practically dry. Even the rainfall in monsoon is erratic and there are evidences to suggest that it is becoming more so in recent years.

TABLE 3

Some Important Information about Major Rivers of Orissa [5].

Name of the River	Origin	Drainage Area in Km^2	Length of the Main Drainage Channel in Km	Peak Discharge in Cumecs	Annual Flow in Mm^3	Main Tributaries
Mahanadi	Parsiya in Raipur district of Madhya Pradesh	1,41,600 (65,579 in Orissa)	851 (494 in Orissa)	44,740 (43,654)	66,640 (51,061)	Seonath, Hasdeo, Mand, Ib, Jonk, Ong & Tel
Bramhani	Nagri village in Ranchi district of Bihar	39,033 (22,248 in Orissa)	800	22,640 (22,654 at head of Delta)	18,810 (at Janapur 18,311)	Karo, Sankha, Tikira, Singada, Sankoi & Chilanti
Baitarani	Ganasika village in Keonjhar district	12,789	365	14,150 (14,158 at head of Delta)	5,755 (5,452 at Akhuapada)	Arredi, Siri, Salandi, Kusai, Kukurkata, Tel, Kanihari, Gohira & Remal
Subarnarekha	Chotnagpur Plat-eau of Ranchi district of Bihar	19,300 (2,123 in Orissa)	395	17,000 (16,990)	7,940 (7,941 at Rajghat)	Kanchi, Karkari & Khadkei
Budhabalanga	Similipal hills of Mayurbhanj district	4,837 (4,847)	164	5,660	2,177 (637 at Kuliana)	Sore, Gangahar, Palpala & Katra
Rusikulya	Daringbari area of Phulbani district	7,753	146	8,495	1,800 (1,762)	Padma, Badanadi, Gadahada & Bhaguva
Bansadhara	Belelaged village of Phulbani	10,800 8,015 in Orissa)	221	4,700 (4,701)	3,500 (3,460)	Paladi, Gangudi, Sananai, Paddagodda, Dhamni and Chudaldhua

Name of the River	Origin	Drainage Area in Km^2	Length of the Main Drainage Channel in Km	Peak Discharge	Annual Flow in Mm^3	Main Tributaries
Nagavali	Gunupur village of Kalahandi district	9,410 (3,746 in Orissa)	217	6,800	2,430	Jhanjavati, Subarnamukhi and Vegavati
Indravati	Indravati hills of Kalahandi district	7,512	185	6,792	2,800	Bhaskel
Kolab	Sinkaram hills of Koraput district	7,639	88	7,358	2,615	Sabari
Machakund	Mudugula hills of Visakha-patnam district of Andhra Pradesh	4,963 (1,478 in Orissa)	192	9,140	4,044	Gurepreonala

* Values in the parentheses are those collected from the Irrigation Department of the Government of Orissa
Cumecs = Cubic metres per second M = million

When water is taken from a river to farms for irrigation, the water is transferred from the river to the soil and then to the atmosphere from where it returns to the river only partly. All evapotranspirations from the irrigation water condense into rain water but do not precipitate in the basin of the river from which water is used. Further, only a part of the rainfall in the basin seeps into the soil or evaporates In this process, imbalance in the existing water resources is created due to irrigation projects. Besides there are environmental impacts on soil, vegetative cover etc. due to irrigation projects, some of which have adverse effects.

Target and Achievement : Toe National Agriculture Commission has estimated that the gross area required for irrigation in Orissa is 4.3 million hectares (Mha) by 2000 AD and 6.7 Mha by 2025 AD. A draft master plan for irrigation development has been prepared for irrigating 5 9 Mha in the state out of which (i) 3.949Mha will be served by 64 major multipurpose projects and 94 medium irrigation projects and (ii) 1.951Mha by minor (flow or lift) irrigation. 6]

The total irrigation potential of the state in the preplan period was less than half million hectare from all sources. Importance was given to irrigation from the start of the second five-year plan. The planwise development of irrigation projects is given in Table 4.

TABLE 4

Planwise Potential Development of Irrigation Projects in the State (in thousand hectares)

Period	During	Cumulative
Preplan period	455	455
1st plan (1951-56)	4	459
2nd plan (1956-61)	363	822
3rd plan (1961-66)	127	949
Annual plans (1966-69)	181	1130
4th plan (1969-74)	59	1189
5th plan (1974-78)	187	1376
Annual plans (1978-80)	100	1486
6th plan (1980-85)	127	1613
Proposed in 7th plan	152	1765

As can be seen from the table, about 1.6 Mha land has been irrigated by the end of the 6th plan period which constitutes slightly less than 25% of the total cultivated area of about 6.58 Mha in the state. Of this, about 0 33 Mha land has been irrigated by minor (flow) irrigation, 0.2 Mha by lift irrigation, 0.27 Mha by other sources (non maj.r projects) and the rest through major and medium projects (Table 5). With this experience, the draft master plan for irrigation of 4.3 Mha by 2000 AD appears like a lotus eater's dream. However, there are at present about 15 major and 33 medium ongoing irrigation projects which, after completion, may increase the irrigation potential by about 1 Mha.

Tacle 5

District-wise and Source-wise Irrigated Area (Potential Created) in Orissa upto 1985-86

District	Major & Medium Projects		Minor (flow) Projects		Minor (lift) Projects		Other Sources		Total (from all) sources	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Balasore	84.74	18.18	6.97	1.90	37.81	22.69	5.00	5.00	134.52	47.77
Bolangir	49.79	21.65	15.92	1 90	6.27	3.76	42 32	42.32	114.30	69.63
Cuttack	196.72	103.08	15.45	—	59 24	35.54	47.89	47.89	319.30	189.51
Dhenkanal	18.47	9.77	28.41	—	12.50	7.50	22.00	22.00	81.38	39 27
Ganjam	101.17	3.39	105 59	—	17.24	10.34	22.90	16.40	246.90	30.13
Kalahandi	12.67	4.20	20.02	4.72	7.70	4.62	22.07	22.07	62.46	35.61
Keonjhar	14.74	2 12	13.71	0.63	7.24	4 34	4.77	4.77	40.46	11.86
Koraput	33.99	15.25	20 03	1.05	16.68	10.01	18.50	18.50	89.20	44.81
Mayurbhanj	24.52	7.87	24.38	—	10.95	6.57	9.00	6.00	68.85	20.44
Phulbani	22.26	3.22	12.88	0.44	4.82	2.89	9.19	9.19	49.15	15.74
Puri	168.51	114.51	23 60	2.38	10.60	6.36	18.35	14.33	221.06	137.58
Sambalpur	126.47	85.76	28.05	1.61	10.06	6.04	35.14	35.14	199.72	128.55
Sundergarh	7.88	4.67	14.57	1.32	7.60	4.56	15.42	45.47	45.47	25.97
State total	861.93	396.67	329.58	15.95	208.71	125.22	272.55	259.03	1672.77	796.87

Unusual Delay of Implementation of Large Projects. The reason for this woefully poor progress of irrigation is not difficult to find It is due to our undue emphasis on the major and medium projects in the immediate post-independent period. The capital investment on major and medium irrigation projects is much higher than on minor projects and the gap is increasing with the increasing cost of materials for dam construction (Fig 3) To be fair there has been a spurt only during the five year period from 1980-81 to 1985-86 when the irrigated area has increased considerably—mostly through the increase in the irrigation potential created due to the implementation of several minor irrigation projects distributed all over Orissa (9).

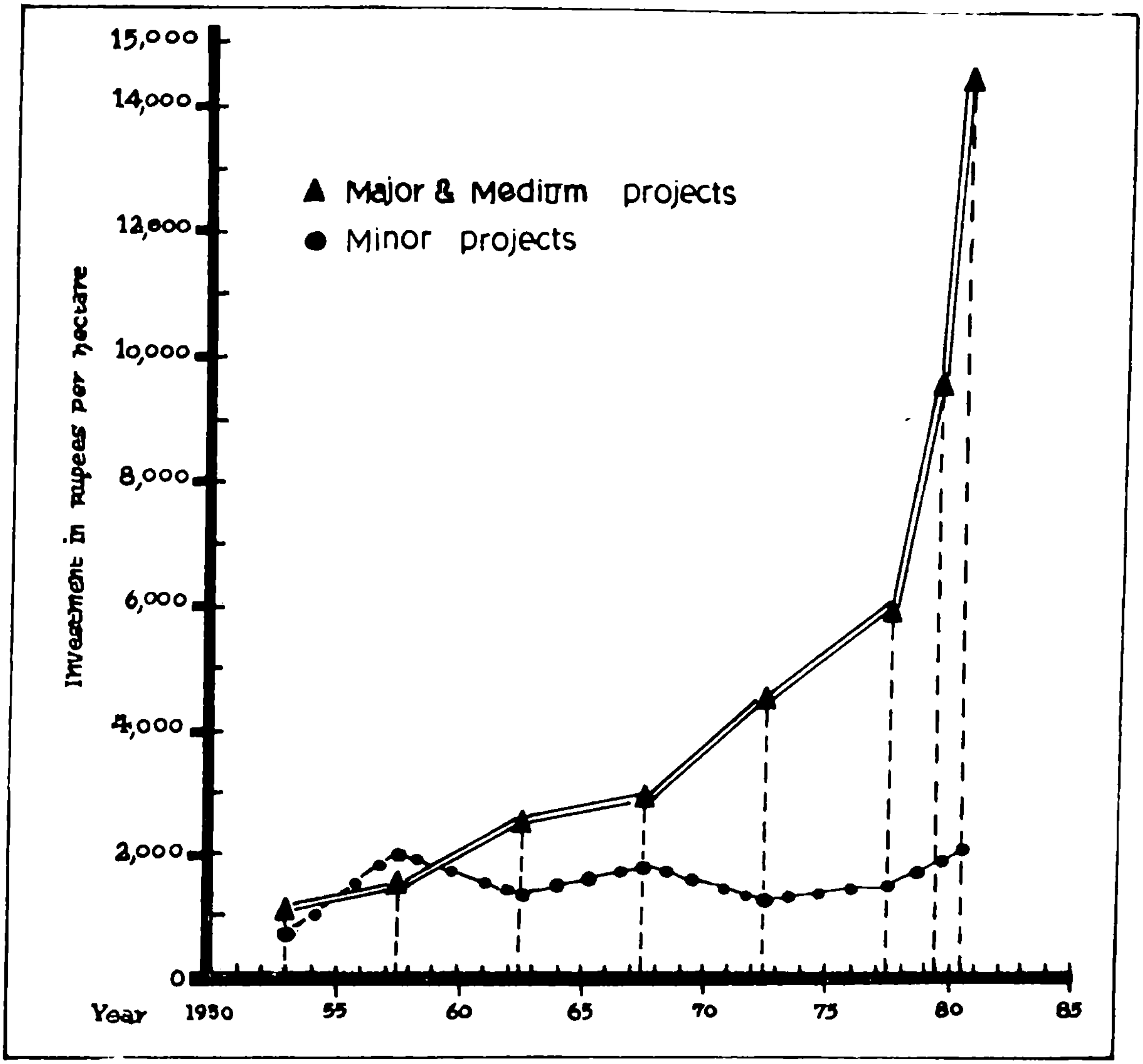


Fig-3 Cost of investment in various projects (7

It is often observed that large new multi-purpose projects are taken up before the completion of the irrigation network of former projects due to resource constraints. New projects are taken up while maintenance of existing irrigation projects is neglected. It has also been noticed that irrigation projects are sometimes officially declared completed without construction of field channels for which proper utilisation of water is delayed retarding irrigation and agricultural output. The following are a few examples in the state.

The largest of the multipurpose projects in Orissa, the Hirakud Dam Project, started in 1951. The main dam was completed and water impounded in 1956 but the irrigation system with the field channels took 15 years to be completed in 1971 ! In the meantime work of another major project like the Salandi Project was started in 1960, but it took another 15 years to be completed. The Potteru Project has started in 1972 but is not yet complete. Nor is it likely to be completed before 1990 as per the latest estimates. The Rengali Project, aimed at harnessing the mighty river Brahmani, was started in 1973. The main dam has been constructed and water impounded. The work on the canal system is in progress but the date of completion is uncertain. In the meantime 15 years have already passed.

Without fear of any contradiction, it may be stated that no irrigation or hydroelectric project has been complefed on time and within the cost estimates or anywhere near. As a result, the shortfall in the irrigation potential target and the actual achievement has become large and is getting larger day by day. The delays in the execution of major projects naturally create misgivings in the minds of people In this connection, comments of an eminent scientist and former Chairman of the Centrel Ground water Board, Dr. B B Vohra, is worth mentioning [10].

"Although very large investments have been made on big irrigation projects, their productivity continues to be disappointingly low. The situation can be improved if more attention is paid to command area development programmes than to construction of new projects. Such a major change in policy is however something the irrigation establish ments are reluctant to accept, inspite of the fact that new projects have ceased to be either costeffective or ecologically desirable.

Even the Prime Minister has been critical of the irrigation planning in the country. In an address to the state irrigation ministers in July, 1986 he said [10].

"The situation to day is that since 1951, 246 big surface irrigation projects have been initiated. Only 65 out of these have been comple ted 181, are still under construction This is not a happy state of affairs. We need some definite thrust from the projects that we started after 1970. Perhaps we can safely say that almost no benefit has come to people from these projects. For 16 years we have poured money out The people have got nothing back, no irrigation, no water, no increase in production, no help in their daily life. By pouring money out to a few contractors or a few thekedars and labourers to build canal or may be the Public Works Departments to construct the dam, we are not really doing our people any favour. The favour comes when the project is completed, when the benefits of the project starts flowing".

Some realisations seem to have come of late. It is now becoming increasingly difficult to get funds from the Centre or the World Bank for new projects before the old ones are completed. Construction of field channels for irrigation of 5 hectare blocks and proper water management proposals are insisted upon in the original pro-project reports.

The Major Command Areas of Orissa and Their Environmental Problems. There are four major command areas in Orissa where on-farm development works including field shaping, field grading, layout of field irrigation and drainage systems and cropping programmes (diversification and multiple cropping) are entrusted to the Command Area Development Authority (CADA) to maximise the benefits from the costly irrigation projects. Needless to say that command area management is more important than the construction of the reservoir and the main canal. Yet it

happens to be the weakest link in our entire irrigation and water management system.

The four major commands include three coastal commands comprising Mahanadi Delta Stage I (Cuttack delta or Old Mahanadi delta) Mahanadi Delta stage II)Puri delta or new Mahanadi delta) and the Salandi Command in Balasore district.

The fourth command is the area included in the Hirakud irrigation project situated in the upper reaches of Mahanadi in the Sambalpur district. The total irrigation potential of the four major commands has been estimated to be 5.36 lakh hectares (Table 6). More command areas are being developed in Ganjam and Koraput districts.

Table 6

Major Command Areas of Orissa [9]

Name	**Total (in thousand ha)**	**Potential Created (in thousand ha)**
Mahanadi Stage I (Old delta, Cuttack)	179.41	163.64
Mahanadi Stage II (New Delta, Puri)	156.89	156.89
Salandi (Balasore)	42.37	42.37
Hirakud (Sambalpur & Bolangir)	157.C0	153.21
Rushikulya (Ganjam)	61.79	61.79
Poteru (Koraput)	70.10	NA

Major areas in the coastal commands are plain lands which are essentially flood plains with a slight slope towards the sea The deltas are divided into a number of sectors or "*doabs*" by the different branches of the main rivers. The highest points of the doabs are usually along the natural river levees from which the lands slope down gradually to the centres of the doabs where natural depressions and drainage— ways are found to eventually discharge water into the rivers near the coast or in some cases, to sea or lake. The main branch canals follow the river levees with distributaries and minors leading to the central portions of the doabs. The flooding of these areas have been accentuated as the result of expanded irrigation in the deltas. One of the characteristics of the coastal commands in relation to the irrigation system is that the outlet points of the canal systems are not always provided in the highest contour, as a result of which, a portion of the command area does not always get water and besides this, flooding is caused in areas adjacent to the outlet points. One is therefore tempted to conclude that efficient drainage is not given due importance during the construction of canals. It is observed that, in many cases, some drainage channels have not been excavated to the design section towards the tail-end [6] The drainage channels are also not maintained properly. To add to this problem,

at the local Block Development Officers' level, village roads are constructed without adequate ventage for bridges over the drainage channels causisg stagnation of water in the upstream Also cross bunds are put during drought months, financed by the government, which are not removed before the monsoon.

During rainy seasons, vast stretches of lowlands in the flat plains remain submerged for considerable durations because of lack of adequate drainage. Certain parts of the command aıeas are also innundated during peak periods of river floods and cyclonic storms occurring towards the later part of monsoon.

The drainage condition of the Mahanadi delta is assuming serious proportion and the crop yields are showing decreasing tendency in many areas. ***It is estimated that about one third of the irrigated area of the Mahanadi delta suffers from the malady of water-logging in different degrees.*** Thus, out of the total CCA of 0.336Mha of Mahanadi delta irrigation project, about 0.1142 Mha of land suffers from varying degree of poor drainage and consequent salination and alkalisation *[9 11]* as shown in Table 7. It is also estimated that at present about 0 1106 Mha of the command can be improved leaving the balance 3600 ha of the ill-drained land which cannot be economically retrieved. These lands will remain water-logged and can only be used for pisciculture, duck ponds etc.

Table 7

Doabwise Distribution of Ill-drained Areas in Mahanadi Command Areas (in lakh ha)

Doab	**GCA***	**CCA****	**Area affected**
State I			
1. Mahanadi—Kathjuri—Devi	1.0	0.61	0.215
2. Mahanadi—Chitroptala—Luna—Birupa—Bramhani	1.27	0.83	0.309
3. Luna—Chitroptala	0.15	0.09	0.027
4. Area to the east of HLC Range—I	0.23	0.14	0.032
Total I	2.65	1.67	0 583
Stage II			
1. Kathjuri—Kusabhadra	1.00	0.53	0.203
2. Kusabhadra—Bhargabhi	0.52	0.28	0.112
3. Daya—Bhargabhi	0.89	0.47	0.203
4 West of Daya	0.14	0.08	0.041
Total II	2.55	1.36	0.559
Grand Total (I+II)	5.20	3.03	1.142

* GCA = Gross Command Area

** CCA = Culturable Command Area

Rice crops in the water logged areas are also found to be easily infested with pests like stem-borers in the coastal command areas. This happens mostly in the earing stage in the month of November. Problems of aquatic weeds are also observed to be increasing in water-logged areas causing problems of health and drainage.

The Hirakud command area has a flat terrain with undulating and folded topography. The lands having slopes (constituting about 4% of the total) have been terraced to make them fit for irrigation farming. On the basis of the topography and elevation, the lands in the Hirakud command are classified as "***Aat***" land (land located at the highest contour), "***Mal***" land, "***Berma***" land and "***Bahal***" land (land at the lowest contour). The Aat land soils are generally highly leached, porous and less fertile. The Bahal land soils have inherent high fertility and are usually fine-textured The introduction of canal water has brought in water-logging problem in Bahal lands which were considered most productive during the pre-project period. ***About 7-10% of CCA is reported to be suffering from water-logging*** *[9]*. Another problem introduced due to irrigation in this area is the continuous build-up of transient high water table, even in high and medium lands, as water starts running through the canals. This keeps the soil sufficiently moist to prevent the growth of medium and light duty crops *[9]*.

The Orissa Remote Sensing Application Centre (ORSAC) has done a rapid reconnaisance and analysis of water-logged lands in the State referring to setellite imageries (The Landsat I imagaries of November 18-21, 1975) of the IBRD (International Bank for Rural Development) and the NRSA (National Remote Sensing Agency). According to their finding, water-logged lands (swamps/marsh lands including wetlands, flooded fields) in different districts are as follows.

Table 8

Water-logged (Swamps/Marsh-lands, Flooded Fields etc.*) Lands in Different Districts *[12]*

District	Area (in thousand hectares)
Balasore	6.36
Bolangir	3.36
Cuttack	21.36
Dhenkanal	0.87
Ganjam	5.86
Kalahandi	6.32
Keonjhar	0.99
Koraput	3.82
Mayurbhanj	1.21
Phulbani	1.12
Puri	13.95
Sambalpur	7.73
Sundergarh	1.81

It is to be borne in mind that the analysis is based on an old imagary of 1975. Further, remote sensing data need to be substantiated by ground data to be fully acceptable. Nevertheless it can certainly be indicative.

* Not to be equated with "ill-drained areas" of Table 7.

Irrigation by Groundwater Orissa has varied rock formations ranging from Archean to Recent out of which Archean and Preterozoic formations are consolidated in nature and do not form aquifers except when weathered, fractured or lying in tectonically disturbed zones. The water yielding capacity of these formations is very often limited. Groundwater generally occurs under water table conditions in the near surface weathered and fractured zones and circulate through deeper fractures. The tubewells sunk by the Central Groundwater Board in such zones in Kalahandi, Mayurbhanj and Dhenkanal, at ranges from 22-171 metres below ground level (mbgl) discharge water at varying rates, e.g., 100 litres per minute (lpm) in Kalahandi and 120-650 lpm in Mayurbhanj. The Phenerozoic sedimentaries include Gondwana sandstones, shale and Baripada beds and occur in Dhenkanal. Sundergarh, Sambalpur, Puri, Cuttack and Mayurbhanj districts. Gondwana sandstone forms moderately potential aquifers. Groundwater in Gondwana occurs in water table conditions near surface aquifers and in deeper aquifers, in confined conditions. It is obtained in depths of 7 to 9.5m deep. But in Baripada bed, it occurs at 4 to 9 mbgl In the alluvium zone of coastal area, water is found under unconfined conditions in shallow zones and under confined conditions in deeper zone with water discharge of 1800-4600 lpm from tubewells and water level varying from 2 to 12 mbgl [*2*].

According to the norms of the Groundwater Estimate Committee of the Government of India, the annual replenishable groundwater resource in Orissa is 2.33 Mham. The groundwater draft is mainly through dugwells or tubewells. It was a meagre 0.0949 Mham in 1985 ***which is about 4% of the available amount*** [*2*]. As per the estimation of the Lift Irrigation Department of the Government of Orissa, the available groundwarter resources in the state is approximately 1.98 Mham [*13*]. At the national level, the total groundwater draft is of the order of 10.45 Mham out of the total resource of about 45.66 Mham. The utilisation is therefore about 25% [*14*].

The available groundwater can easily sustain an installation of 11,865 public tubewells, 28,400 filter-point tubewells and 10.16 lakh standard dugwells to create irrigation potential for 1.621 and 0 972 Mha respectively for Kharif and Rabi seasons in addition to providing drinking water.

The number of different types of irrigation wells so far installed are given in Table 9.

Table 9

Different Types of Irrigation Wells Installed [*13*].

Type of Irrigation Well	No. Installed	Irrigation Potential Created in Hectares	
		Kharif	Rabi
Public tubewell	4,384 (by 3/87)	69,994	41,996
Shallow filter-point tubewell	3,191 (by 3/87)	9,573	5,744
Dugwell with pump	12,609 (by 3/85)	15,763	9,457
Dugwell with indigeneous water lift (Tenda)	1,92,413 (by 3/85)	76,966	46,178

All these irrigation wells have so far harnessed only about 4 to 5 5% of the utilisable groundwater potential in the state according to different estimates. This is the lowest figure for any state barring Assam and the North-eastern states While some states like Gujarat, Maharastra and Tamilnadu have problems due to overuse of groundwater, where in certain areas, withdrawal of groundwater is in excess of the annual recharge, Orissa suffers from gross underuse

Table 9 does not give the figure of the number of lift irrigation pumps that are, on the average, in a state of unuse at any given point of time due to problems of maintenance and energisation. The number may be substantial.

Groundwater for irrigation has many advantages over the surface water. Firstly, groundwater reservoirs do not suffer from serious seepage losses Loss due to evapotranspiration is also minimum Groundwater irrigation wells, being located near the place of use, irrigation is comparatively cheap. Further, groundwater is less likely to be polluted compared to surface water.

Many experts feel that widespread use of groundwater for irrigation in the Indo-Gangetic plains is the key to the success of the so-called green revolution According to Dr Vohra,

> "It is not merely an accident that the green revolution should first have taken root in precisely those regions—the alluvial plains of the Northwest and the South - where groundwater is not only most readily available but also been tapped for irrigation to the greatest extent" *[15]*

Perhaps groundwater irrigation in our coastal plains and deltaic regions would have given us better returns than the surface water irrigation through canals, had we given due emphasis to lift irrigation in the past Besides, environmental problems would have been much less

Neglect of Tanks. The age old methods of irrigation by tanks seem to be out of favour by our planners and administrators. Tank irrigation was prevalent in ancient India and continued as a predominant mode of irrigation almost till our independence. Every village had atleast one community tank Zamindars possessed privately-owned tanks. No temple was conceived without a tank. To day almost all are in a very bad shape and in the state of disuse. The causes for this are many.

In pre independence days, private tanks and tanks belonging to temples were zealously guarded. With the availability of diesel as well as electric pumps, private cultivators preferred to instal tubewells for irrigation rather than to maintain their tanks. Disciplined use and maintenance of community tanks were ensured by the autocratic and repressive zamindars with "danda" power. Post independence India does not have the earlier discipline in the villages. Consequently village tanks got neglected and finally became unusable. Runoffs from surrounding agricultural fields and homestead and pasture lands carrying fertilisers and organic wastes entered the tanks facilitating algal growth and growth of other organisms. As the organisms died and decayed in the water bodies, they caused anaerobic conditions inside setting in eutrophication. In the process, tanks ultimately got converted into virtual swamps. To day we hardly find a community tank which is not eutrophic. Most of them, a generation before, were healthy and oligotropic water bodies. Even small natural lakes are suffering from eutrophication - a natural process accelerated in recent years due to anthropogenic activities A case to cite is the lake "Ansupa" in the Athgarh sub-division of Cuttack district. Fifty years ago it was a recreational spot and source of good fish. Today it is almost a swamp.

Many agricultural experts have started realising tank irrigation as being economically productive and profitable and also ecologically compatible. Dr D. R. Bhumbla, former Agriculture Commissioner of India believes that tanks are very important for good water management and can even substitute for canal irrigation in medium (750—1150mm) and high (over 1150 mm) rainfall areas [16]. Problems of waterlogging caused by canal irrigation and the consequent decrease of the productivity of the land could atleast be partially avoided by supplemental tank irrigation It is not uncommon for farmers in Orissa to allow about 30-40cm of water to continue to stand in July and August to tide over subsequent dry periods in non-irrigated areas This results in reduced tillering and low crop yields Such a practice will not become necessary if tank irrigation is assured for dry months.

Tanks are also useful for recharging wells and for providing drainage during high rainfalls. The premier town of Orissa, Cuttack, to day gets seriously waterlogged even with 5-6cm of rain, because almost all ponds and most of the low-lying areas have been reclaimed for habitation. The northern town of Balasore was full of ponds during the prewar period which made it infamous for mosquitoes and malaria Now most of the ponds are earthfilled and rest are left unattended As a result, drainage problem has cropped up. Mosquitoes, though initially controlled by the malaria eradication programme, have come back with a vengeance. Malaria may follow.

Construction of tanks may not be cost-effective in areas of high population density and where land is costly. In such situations, ground-water recharge systems like percolation tanks can be built Nevertheless, the importance of tanks can be realised from the following words of Dr Bhumbla.

> "There is absolutely no doubt that if stress is laid on management of rain water by storing the excess runoff, the average production of rice can be raised to 120 millions tons and wheat to 70 million tons in the next 5 to 10 years".

We seem to have recently forgotten the age-old wisdom of the utility of tanks. Perhaps it was so because tanks are considered ineffective for irrigation during extreme droughts.

Irrigation by Wastewater. As per WHO's recommendation, superior quality water should not be used for purposes where an inferior quality is adequate. This is plain commonsense. For example, filtered water need not be used for gardening. The total urban piped water supply in Orissa in 1987-88 was about 316 Mld (million litres per day) It is estimated that about 80% of urban water supply is generally returned to the environment as sewage water [17]. On this basis, about $1 \times 10^8 m^3$ of sewage wastewater is being discharged into our rivers or simply allowed to soak into the land through soak pits or septic latrines per annum. This necessarily causes pollution of the river or the shallow groundwater. Urban sewage, or even industrial effluent, can easily be used for irrigation to grow edible or inedible crops after inexpensive primary treatment. If wastewater is properly and scientifically discharged onto land, the latter does not merely act as a "receiving body" but also acts as a "treatment unit". According to the US Environment Protection Agency :

> "In the past, the ability of soil to treat wastewater was not well-recognised. As a result, the discharge standards were often imposed on wastewater prior to its application on land, thereby increasing treatment costs and energy requirements without significantly improving overall treatment performance. More recently land has been recognised as an important component in the treatment process" [18].

The versatility of land to treat wastewater has been convincingly demonstrated in the well-

known Muskegon project in the state of Wisconsin near Milwakee, USA In this project, 27 million gallons of municipal and industrial wastewater is treated per day over about 11,000 acres of previously unproductive land [19] Apart from satisfactorily treating the wastewater at very low costs, the project completely protects the lake Michigan from pollution which was previously receiving almost whole of the wastewater, and also produces over a quarter million bushels of corn annually (1975 figure)

The Muskegon experience is worth trying in Orissa which is likely to be more successful here in a hot and humid climate Barring a few, most of the rivers in Orissa and for that matter, in most of the Peninsular India, are not perennial and are almost dry during summer months. Any sewage or effluent, however well treated, does not get diluted to the desired level when discharged into such rivers Application on land is therefore an attractive alternative solution, particularly in arid and semi arid areas The importance of land application of wastewater has been implicity recognised in the Water (Prevention & Control of Pollution Act, 1974. Section 17 (i) of the Act prescribes the following as one of the functions of the State Pollution Control Boards :

"to evolve methods of utilisation of sewage and trade effluents in agriculture"

Land application of municipal sewage or industrial effluent is not recommended where soil is very impervious and saline and also if the groundwater table is high Wastewater containing high proportion of sodium or highly toxic substance like mercury is particularly not suitable for irrigation

This simple and potentially very attractive method of disposal of wastewater has not yet touched the imagination of the engineers of Orissa. Perhaps our outdated revenue laws need to be amended to allow permissive use of government land for the sole purpose of irrigation by sewage or effluent water to generate vegetative cover This will help reclamation of many wastelands — or more appropriately, wasted lands — which is a national objective.

Muskegon method is being experimented with the effluent of the Orient Paper Mill at Brajarajanagar, Sambalpur District over about 400 acres of wasteland.

Creek Irrigation. The Government of Orissa has taken up the programme of utilising water in the creeks of the coastal areas for irrigation. It is proposed that by constructing controlled structures in the mouths of the creeks and improving the channels, saline intrusion can be prevented. The sweet water available will be used for irrigation. Some areas in Balasore district have recently been irrigated by water from creeks. Another 11 number of such schemes are proposed to be operated within the next two years to provide irrigation for additional 20,000 ha of land [4]

It may be pointed out here that the flora and fauna rich thick mangrove forests, which were once the main characteristic features of the deltaic regions of coastal Orissa, have almost vanished except at a few pockets. Mangrove forests thrive because of the very saline intrusion If that is prevented, the forests will die a natural death Moreover, the creation of barriers accross the paths of migrating fishes like Hilsa can undermine their survival It is not known if the above aspects have been taken into consideration in the project reports We only hope that creek irrigation will not be taken up in areas where mangrove forests exist and adequate attention has been paid to proper designs of engineering structures to effectively help the fishes to cross the hurdles (e.g., simple fish ladder, mechanised lifts etc).

Conclusion The purpose of the aforesaid discussions is not to discourage irrigation through the conventional or currently-esta-

blished modes. In fact, irrigation works have to be accelerated in the coming years, at least to complete the ongoing projects. What is intended is only to drive home the point that emphasis must shift to proper land, water and crop management which are more important than the mere construction of reservoirs and main canal systems. No doubt, food production has increased considerably in the last two decades through increased cropping and cropping intensity. Two or even three crops are grown in a year in areas where one crop was grown previously after irrigation water was made available. High yielding hybrid varieties of paddy and other crops are almost totally replacing the traditional resistant varieties. But this has resulted in increased use of fertilisers and pesticides with consequential environmental problems. Crop production in the irrigated lands has undoubtedly increased ***but not the productivity***. The water, fertiliser and other inputs are increasing at a faster rate than the crop output. A situation may arise when the energy input (in terms of fertiliser, pesticide, water etc.) may grossly exceed the energy output measured in terms of crop production as has already happened in some industrialised countries, atleast with respect to some crops, e.g., corn in the USA.

Further, considering the poor financial resources in this country, major irrigation projects must not be allowed a long gestation period. ***No new project should start until the previous ones are completed and start giving positive returns.*** Small and less cost-intensive schemes (e.g., tank irrigation should not be neglected in favour of big and grandiose projects. They give quick returns to the poor farmer and are generally ecologically more compatible.

In a well researched report of the economic aspects of irrigation projects in Orissa, Dr T. Satpathy of the BJB College, Bhubaneswar has clearly pointed out that three primary reasons for the tardy expansion of irrigation facilities in Orissa are: (i) lack of adequate institutional support to minor irrigation projects, (ii) poor progress of rural electrification which is an important infra-structural requirement for minor irrigation and (iii) continuous spillover of all types of irrigation projects with repeated advancement of scheduled dates of completion *[20]*.

Environmental aspects are essential to be studied before embarking upon the implementation of large irrigation projects so that mitigative measures could be duly incorporated in a project right from its inception. The Government of India in the Ministry of Environment and Forests has made Environmental Impact Assessment (EIA) study compulsory before clearing major irrigation projects. This study is unfortunately not being done the way it should be, perhaps due more to a lack of enthusiasm on the part of the Establishment than to any lack of expertise—a management deficiency which can easily be taken care of.

FLOODS—THE UNMITIGATED PROBLEM

The State of Orissa lies along the path of storm which causes heavy precipitation during the monsoon months. The following rivers, their tributaries and branches, regularly get flooded and often cause heavy damage to life and property: Subernarekha, Budhabalanga, Baitarani, Bramhani, Mahanadi, Rushikulya and Vansadhara. About 31,000km^2 of the coastal deltaic region is particularly prone to flood problems.

Flood Control Methods. Generally the following six methods are adopted for the control of flood; each method has its advantages and limitations.

(i) Construction of embankments (dykes flood walls, levees etc.) on both sides of the river to confine the water to the main channel of the river—This is a time honoured method but embankments are subject to breaches and require raising when the river bed rises.

(ii) Construction of reservoirs in the upper reaches of the river to withhold water in excess of the bankful discharge capacity—Reservoirs are capable of moderating the floods but they submerge large areas destroying forest and mineral wealths and displace inhabitants from their ancestral settlements. Besides, there are many adverse environmental impacts of large reservoirs for which they are now subject to intense public debate.

(iii) Channel improvement by straightening, deepening, widening, providing cut offs etc. and river training works—This makes the the river more capable of discharging the flood water at bank level. These works involve heavy recurring expenses and also have engineering problems However, some amount of judicious river training works may be able to maintain deep channel for better discharge of flood water.

(iv) Provisions of escapes or diversions—Diversion of excess flood water from the main channel into auxilliary channels or low-lying areas or to the sea is an approved flood engineering practice. Suitable sites for diversions may however be difficult to find and further, diversions should be provided with regulators (barrage to control excess water from the river at the time of high floods.

(v) Improved land management and soil conservation by vegetation, check dams, contour ploughing etc — These are very important aspects of flood control management but are not given the importance they deserve. The execution of these measures is to be done by different government departments and agencies. But this calls for a high degree of co ordination, which apparently is not being achieved at the moment.

(vi) Construction of spurs and rivetments—These arrest erosion of river banks.

Instead of any single method out of the above six, a conjunctive use of all the methods is a more practical snd effective approach towards flood control This however not the practice in Orissa Greater emphasis here nas been given to the first two methods i e., the construction of reservoirs and embankments.

The Multipurpose Projects When water is stored in the upper reaches of a river in a dam, some amount of flood water from the catchment area is held up and is released at a controlled rate preventing flood in the downstream. Since there is stored water, the project can be integrated to an irrigation project to provide water through a canal system in lean seasons. Furthermore, use is also made of the water head created to generate power by allowing water to fall through turbines. Thus a third objective is introduced into the project. This is how a multipurpose project is conceived.

The oldest and the largest river valley project of Orissa in the post-independent era — the Hirakud Dam Project on river Mahanadi — is a multipurpose dam project with the triple objectives of i) irrigation, (ii) flood control and (iii) power generati n. A similar project on river Bramhani — the Rengali Dam Project — has recently been constructed but the irrigation network is yet to be completed. We may now take stock of our experience with the Hirakud Dam which has come into existence since more than three decades

The two objectives, viz, flood control and power generation are in many respects contradictory. If the reservoir level hight is kept at a high level, the power generation is increased but the flood moderative capacity is decreased If a higher flood cushion is provided by keeping the water level low, power generation suffers due to the reduction of the water head. The operation of the sluice gates of the Hirakud dam for maintaining the optimum water level during rainy seasons is thus a tricky business, particularly towards the later part of the monsoon season Cyclones, cloud bursts etc. sometimes

occur even in the months of September and October as in the year 1980. If the level of water in the reservoir is kept low to accommodate anticipated floods in September and October, the state suffers from power shortage and to some extent, from poor irrigation throughout the year, if floods do not occur. Similarly, if the reservior level is kept high for power requirement but heavy rains occur in the catchment area in September and October, much water cannot be retained in the dam beyond the safety limit. Consequently flash floods occur in the downstream. The flood problem is not mitigated and sometimes, it may be aggravated. No wonder, the engineers at Hirakud in charge of the operation pass many a anxious and sleepless night during rainy seasons. Recent multipurpose projects are however appropriately conceived with provision of separate space for flood absorption; it is to be seen how far it is successful in flood routing as the reservoirs get slowly silted up.

Accurate weather forecasting and correct periodical reporting of flood heights in the tributarises and precipitation in the downstream during flood seasons are prerequisites for successful operation of the sluice gates of the reservoir. But all these are far from perfect at present. These are expected to improve with the development of science and technology unless there are human failures.

Even after the construction of the Hirakud Dam, there have been a recurrence of high floods about once in three years out of which the floods of 1961, 1980 and 1982 were particularly devastating

During these floods, the discharge of water at Naraj—just before the river branches off—some times exceeded the safe flood discharge. This speaks of the important contribution of the precipitation of rains downstream of Hirakud towards flood in the coastal delta. In the 1982 flood, for example, the downstream free catchment contributed a flood of 15.80 lakh cusecs without any release of water from the Hirakud reservoir [21]. It was a particularly devastating flood The 1961 flood is also remembered, not only due to the magnitude of destruction caused by it, but also because of the controversy generated due to the order of the political leadership to retain the water level in the dam at a considerable risk of damage, over-riding the recommendations of the engineers.

The inescapable conclusion from the above is, therefore, that ***the Hirakud dam and the large stretches of embankments have not been able to control the floods of river Mahanadi as effectively as was expected initially***. Of course, the dam has, at times, reduced the intensity of the flood. For example, had the Hirakud dam not retained the water from the catchment completely during the flood in 1982, there would have been a catastrophe in the downstream coastal plains.

So frustrated was a prominent engineer, Shri J. Tripathy, retired Chief Engineer and former member of the Central Water Commission, about the failure of the Hirakud dam to control floods, that he made the following comments.

> "Before Hirakud, we had flood protection embankments along Mahanadi and its branches at certain reaches for protecting certain areas against flood After Hirakud, we have provided embankments on both banks of Mahanadi and its branches almost in all reaches and they have been raised and strengthened. The embankments are now really protecting the delta area. Hirakud is able to reduce the probable flood level by a metre or so and sometimes at the cost of storage. It has also been found twice during this decade that Hirakud could not be helpful in reducing the flood stage and there were flood devastation mostly due to over-topping of the embankments. Even if we

still insist that Hirakud will be operated to moderate the flood, how long can it do so ? The estimated useful life of its storage capacity is about 150 years out of which 30 years have already passed. Silting as usual ~~will continue and say, after hundred years, it~~ will continue and say, after hundred years, it will have no capacity to moderate and we will have to entirely depend on the embankments for flood protection. We have embankments as old as 700 years or more still protecting the area from floods and we can safely assume that these embankments with normal repairs will last millenniums Now if we raise them by a metre or two, they can safely protect us from the highest floods experienced during 1980's. Hirakud can then be left to fill up the reservoir at the earliest possible date and ensure complete power generation and irrigation. In its 30 years time, Hirakud could not be filled in two or three occasions and the loss in power was considerable So, I would strongly recommend that Hirakud can be relieved of its responsibility of flood moderation. Let it be operated to store to the maximum capacity for as long as possible and increase power generation and ensure irrigation, particularly when the state is having acute power shortage.

Reservoir regulation may be able to reduce flood stage but it can never prevent bank erosion. Bank erosion can only be prevented by river training I would, therefore, recommend that all delta rivers are trained for stability in the course of a few decades. Embankments are the first step in river training Then a few other simple steady steps are to be taken for a few years so that the river regime will stabilise to convey its discharge and silt charge to the sea. This has been achieved elsewhere in other countries and it can be easily achieved in our deltas For flood control, let us relieve Hirakud and have a peaceful co-existence with our kindly rivers. But we have to continue to train them, nurse them and they will oblige" *[22]*.

Although the above views of Shri Tripathy may be considered as his personal views to which many other engineers do not subscribe, his wisdom and experience should not be completely ignored.

What is described for Mahanadi, as above, is also true for Bramhani, Baitarani and other rivers of the state.

Reasons for Inadequate Flood Control. The state is maintaining about 4503km length of embankments of the following types to protect towns, villages, roads, industries, agricultural lands etc. from high floods.

Capital embankments	1405.8 km
OA embankments	1679 0 km
Saline embankments	1418 0 km

Besides, about 1365 km of test relief embankments are also maintained by the irrigation department for protection against low floods *[21]*. These measures are in addition to flood — controlling dams over rivers Mahanadi (Hirakud dam , Bramhani (Rengali dam) and Subarnarekha (under construction in Bihar).

Inspite of all these, why are the floods not adequately controlled ? The causes are not difficult to trace They are mainly environmental factors.

The first and the foremost reason is the deforestation of the catchment areas. Forest growth, not only reduces the run-off, but also retains it for sometime during rains to reduce the peak discharge According to Dr Philip Fearnside of Brazil's National Amazon Research Institute :

"When an area is completely deforested, about 10 times as much water runs off because there are simply no roots left in the soil to catch it" [23].

This is the experience gained by their study in the Amazon basin.

Heavy silting of the reservoirs have decreased their water-holding capacity. To add to that, anicuts constructed along the river channel for irrigation have resulted in the rise in the river bed The anicut constructed over Mahanadi at Jobra, Cuttack about a century back, has resulted in the rise of the Mahanadi river bed near Cuttack town to such an extent that to-day the ground-level of Cuttack in many low-lying areas is lower than the river bed.

Lack of adequate flood-way for safe passage of the flood wave in the flood plains is an important factor which contributes towards the severity of a flood. The flood engineers, administrators and even legislators find it difficult to prevent encroachments, obstructions and constrictions in the flood plains which adversely affect the flood water discharge and disturb the flow-regime, both in the upstream and the downstream of the river. Crosswise construction of roads, highways, railway lines etc in the flood plains without sufficient provisions of waterway in bridges, culverts etc reduces the velocity of flow and causes flooding. Late Shri S. N. Bhanja Deo, Rajasaheb of Kanika, former minister of the Orissa cabinet, had certain reservations about the construction of the Daitari — Paradip expressway which, at certain places, runs crosswise to the flood plain. It was later observed that during floods, the afflux near Marsaghai, in the Kendrapara subdivision, goes to nearly 2 to 3 feet in the upstream of the bridge in the highway [24]. Shri Bhanja Deo was not simply a politician-minister. He was also a self-taught expert on flood control and allied matters.

Conclusion Floods have been an annual problem in certain parts of the state from time immemorial Complete elimination of flood in those areas in neither possible nor desirable.

People living in the deltas owe their existence to the floods, because floods in the past have created the fertile lands Floods bring silt with large amounts of plant nutrients in it which are deposited on the flooded lands and if flooding is eliminated, they are flushed into the sea. An old estimate for India, made in 1972, showed that the nutrients annually lost from the soil by erosion amount to about 8.37 million tons in terms of nitrogen, phosphorus and potassium (NPK) priced at rupees 700 crores [25]. These nutrients ultimately go along the water courses with silt Since the surface water flow in Orissa is about 11% of that in India, the annual load of nutrients in the silt of the rivers of the state will be about 0 9 million tons. This calculation, though quantitatively not very accurate, is certainly indicative of the magnitude of plant nutrient loss through our flood waters Thus floods are not without any benefit It is a common experience in the flood prone areas that farmers make good a great proportion of Kharif crop loss due to flood during the subsequent rabi season It is also observed that periodic flushing of land by flood water reduces the rodent population which causes immense harm to crops. These intangible gains from flood are often not properly realised.

High floods and flash floods should no doubt be controlled The foregoing discussions based on our past experience clearly shows that multipurpose dams, as designed earlier, are not adequate for the purpose Reservoirs in the upstream do moderate to some extent the high floods but high dams are not necessarily called for, In any case, there is no wisdom in overusing the existing reservoirs for flood control at the cost of their other uses. A comprehensive approach to flood management involves conjunctive use of all the control methods discussed earlier, Without protection and regeneration of forests, gully plugging, contour farming and other soil conservation efforts in the hilly stages

of the catchment area, flood control attempts by only holding flood water in the reservoir will be fruitless. While the objective in the upstream of the river should be to withhold the water and reduce the rate of flow to the extent possible, that in the downstream flood plains should be to let out the flood water to the sea at the earliest. Protection against floods only by embankments has limitations, and cannot cover all the flood prone areas.

In any case, it is necessary to accommodate floods to some extent People in the flood plains, particularly in the deltaic area, should learn, like their forefathers, to live with moderate floods. The political leadership, the media and other opinion makers have a responsibility to educate the people in this matter.

BIG DAMS AND BIG CONTROVERSIES

Big dams are to-day subject to big controversies. It is expected that whenever a new river valley project is proposed, the persons to be displaced and dispossesed of their ancestral homes and lands will agitate against the project, no matter whatever overall benefit the project may give. But to-day, the anti-dam lobby is not confined to the displaced persons and persons wanting to make political capital out of the agitations of the displaced persons, but includes many prominent scientists, engineers, economists, social-workers etc.

Table 10 gives the vital statistics of six major reservoirs of Orissa.

Table 10

Important Information About Major Reservoirs in Orissa [26]

Sl. No.	Name of the Project	Purpose	Total Catchment Area in Km^2	Submergence Area in Km^2	Dead Storage Level in meters	Gross, Dead and Live Storage Capacity in ham
1.	Hirakud Dam Project	Power : 270 MW Irrigation : 1,57,000 ha(CCA) Flood control	83,400	727 (285 villages)	179.83	GSC : 8,10,500 DSC : 2,26,200 LSC : 5,84,300
2.	Rengali Dam Project	Power : 100 MW Irrigation : 2,61,120 ha (CCA) Flood control	25,250	353	109.72	GSC : 3,91,000 DSC : 92,000 LSC : 2,99,000
3.	Balimela Project	Power : 360 MW	1,895	91 villages	439	GSC : 3,82,280 DSC : 99,109 LSC : 2,83,170
4.	Upper Kolab Project	Power : 320 MW Irrigation : 47,985 ha (CCA)	1,630	122 (44 villages)	844	GSC : 1,21,500 DSC : 28,000 LSC : 93,500
5.	Upper Indravati Project (3 dams at Muran, Kapur & Padagada	Power : 600 MW Irrigation : 1,09,300 ha (CCA)	2,630	110 (95 villages)	625	GSC : 2,30,000 DSC : 81,450 LSC : 1,48,550
6.	Machkund Project	Power : 121.5 MW	755	NA	818.6	NA

Rehabilitation Problem. The immediate public concern in a river valley project is the rehabilitation of persons displaced from the submergence area. This often has a political fallout The usual allegation made against the government is that the compensations given to the evicted persons for the loss of their lands and properties are inadequate This was certainly true in the early days of Hirakud dam construction. This is amply testified in the judgements of Late Shri B. C. Das, the first judicial arbitrator appointed by the government to arbitrate disputes about compensation. Sri Das was known to be an upright and fair minded judge.

More than the rate of compensation, the method of assessment and the manner of payment generally have many faults to find. The poorer section of the people like the tribals, landless labourers, marginal farmers, share croppers etc often become victims of corruption of the lower officialdom in charge of the distribution of the compensation money. It is seen from the Hirakud experience that the weakest section of the society from the submerged area has been totally pauperised after project. The tribals are generally the worst sufferers Their life and culture, integrated with the land and forest, get totally disoriented when they are uprooted from their own environment The monetary compensation cannot substitute their loss of culture and the money soon finds way to the hands of the local liquor dealers or the ***"bhatiwallas"*** as they are commonly called.

The lack of proper rehabilitation policy or poor execution of a policy during the Hirakud period followed by the influx of "nonlocals" to reap the benefits of the project had political fallouts from which we haven't yet recovered completely.

Chastened by the Hirakud experience, the government adopted "land for land" policy for displaced persons in the subsequent projects. For example, some displaced families of the Rengali Project have been settled at Gohira settlement created nearby by clearing a forest area. Thus a further loss of forest area resulted — due to the Rengali project and the Gohira settlement. A new settlement cannot replicate the original one and the original cultural life is hardly revived. The social anthropoligists point out that the sudden loss of the cultural fabric of a society brings in various social problems. Physical facilities like roads, schools, dispensaries in a new settlement are very often provided much later than the establishment of the settlement itself causing much inconvenience to the people in the initial stages.

A case study reported by Shri Chittaranjan Mahapatra and Dr. N. K Bewara of the Department of Anthropology, Utkal University *[27]* shows how the lack of vision and indifference to tribal sensitivities in the resettlement programme of the Indravati project made a group of tribals consisting of about 24 households at Patradora suffer from untold miseries.

A humane rehabilitation policy based on the cardinal principle that "the sufferers of a project must be the first people to get the benefits out of it" can go a long way in mitigating the sufferings of the displaced persons in any project. ***A codified and comprehensive guideline for rehabilitation programmes is called for.***

Deforestation and its Consequences. The main objection to large dams is the forest loss caused by the submergence and consequent adverse impacts on the environment.

It has been established beyond doubt that massive deforestation has taken place around all dams in India including their catchment areas and there have been practically no exception to it. These are the areas where trees are most needed for the life, safety and proper functioning of the dams.

An idea about the magnitude of deforestation around reservoirs can be had from the detailed study made by two scientists, Sri A. Mishra and Dr. M C. Dash of the Sambalpur University on the forests in the Sambalpur and Jharsuguda subdivisions within 20 miles radius situated near the Hirakud reservoir (*28*). Their comparative study of the Survey of India topo maps of 1929 and the land satellite imageries in false colour combination (FCC) of 1975 indicated ***a loss of 43% and 46% of the reserve forests around Sambalpur and Jharsuguda respectively***, besides other forest types The deforestation was found to be an accelerating process and the rate of loss was particularly faster since 1950 (after developmental plan periods came into action). According to the estimates of Mishra and Dash, the average rate of losses of forests between 1929 to 1975 around Sambalpur and Jharsuguda were 2.75 and 2.78 hectares per day respectively.

When a new dam is commissioned, a large water body is created. Alongwith this, there is a large scale deforestation in the area not only due to the dam itself but also as a result of various anthropogenic activities during and after the dam construction. These two factors are bound to perturb the micro climate of the area. Mishra and Dash have also collected the various climatic data of Sambalpur and Jharsuguda in the recent years and fed to a computer to get trends of change, if any The analysis of the data indicated decrease in rainfall, number of rainy days in a year and morning relative humidity. These were significantly correlated with the decrease of forest cover. The mean minimum and maximum temperature, evening relative humidity and the atmospheric pressure showed increasing trends. The decreased number of rainy days in a year is particularly disturbing, for it means monsoon to be more erratic now than before. The decreased morning relative humidity after the creation of a large water body is rather surprising. This indicates that the vegetation loss could not be compensated by the reservoir to provide atmospheric moisture in the night time because the total evapotranspiring area of dense multistoried forest is much higher than the evaporating surface of an artificial lake created at the cost of forests. The climatic trends in Sambalpur Jharsuguda area are very early symptoms of a possible desertification process.

Dr. B N. Sahu, Retired Professor and Dean, Department of Agronomy, Orissa University of Agriculture and Technology, Bhubaneswar believes that the Hirakud dam has changed the path of monsoon making the rainfall in Padampur subdivision of Sambalpur district, the Patnagarh and Titlagarh subdivisions of Bolangir district very erratic *[29, 30]*. These areas have either drought or heavy rainfall According to him, the large volume of water vopour from the reservoir get condensed by the dust produced from industries in Bargarh and Rourkela. Thus ice crystals and cloud condensation nuclei are formed over the reservoir and on the windward side of Barpahar-Harisankar-Gandhamardhan hill range which is the path of the south-west monsoon. This monsoon wind charged with moisture is more often blown away io Madhya Pradesh and the Narmada basin causing drought in Padampur-Patnagarh-Titlagarh-Nuapara belt of the Western Orissa. Dr Sahu's hypothesis is not based on any detailed observations or experimental findings. It may not withstand rigorous scientific scrutiny, but it will not be wise to completely ignore his contentions on such a serious matter. The author himself has strong reservations about the hypothesis.

The change in the local climatic pattern is not confined to areas around the Hirakud reservoir; it is probably also felt near other reservoirs Detailed studies are, however, available only on Hirakud. The spillway of the Chitrakonda dam of the Balimela project in Koraput district was designed to store water upto 50?m. It seems that the reservoir has not been full since quite sometime and water has not flown over the spillway. Besides, the maximum water level in the reservoir is continuously decreasing since last few years as can be seen in Table 11, indicating decrease in the precipitation in the catchment area or overdrawal of water.

Table 11

Maximum Water Level in the Chitrakonda Dam (in metres) *[25, 26]*

Year	Water level	Year	Water level
1980	497	1983	494
1981	496	1984	491
1982	494		

Destruction of gene-pool following submergence and subsequent massive deforestation in and around a project area is one of the environmental concerns which the project engineers, not trained in biology, often fail to appreciate Preservation of the genetic diversity is an essential requirement for sustained evolution in nature. It is also equally important for the development of different plant and animal species of desired characteristics through genetic engineering in future. In the fields of agriculture, for example, there is continuous research to develop more high-yielding and pest resistant crop species This could be possible only if wide variety of species are available for hybridisation

The biosphere in certain parts of Orissa is unique. It contains species which are characteristic to that area and not found elsewhere The Chitrakonda hill range, for example contains flora and fauna of the Deccan plateau and the Vindhya-Aravali Zones. The typical bison (***Bos gauras***) population of this area is now under threat of extinction, thanks to the Machkund-Sileru project.

According to some scientists, the Jeypore tract of the Koraput district is the centre of origin of cultivated rice. All the wild and cultivated varieties of rice are native to this area. ***Oryza glaberima***, the west African variety of rice has been collected at Papadahandi. Eighteen varieties of rice resembling the temperate ***Japonica*** type have been collected from Malkangiri subdivision. These types are now in danger as a consequence of destruction of forests and submergence of lands *[29, 30]*. It will be really very disappointing if such valuable genetic resource is lost.

We do not know what genetic resources we have lost in the past during execution of different projects At least sufficient precautions should be taken for feture. Creation of biosphere reserves near all large project sites can be a method to preserve the indigenous species. Creation of biosphere reserves is one of the recommendations of the Govornment of India in the Ministry of Environment and Forests ***[31.]***.

Silting of reservoirs as a direct consequence of forest loss in the catchment area is a problem in the whole of the country. It is rather a global problem to s me extent. Silting causes loss of storage capacity of a reservoir thereby hampering its efficiency of flood control and capacity for irrigation The life of the dam is also considerably reduced. ***It is almost established by now that the expected life spans of most of the reservoirs in the country are much less than those mentioned in the original project reports.***

Take the case of Hirakud dam. Its original capacity was 8, 105 Mm^3 (0.81Mham). As per the hydrographic survey report of 1981 ***[32]***, corroborated by remote sensing study ***[33]***, it has been reduced to 6,626 Mm as shown in Table 12.

Table 12

Storage capacity of Hirakud Dam Reservoir in 1981 [32]

Type	Original capacity (in Mm^3)	Capacity in 1981 (in Mm^3)	Silt Deposited (in Mm^3)	Annual Percent Loss
Dead storage (Below RL 179.83m or 590 ft)	2,262	1,517.22	744.78	1.267
Live storage (Between RL 192.02 to 179.83m or RL 630 to 590 ft)	5,843	5,109.19	733.81	0.483
Gross storage (RL 192.02m or 630 ft and below)	8,105	6,626.41	1,478.59	0.702

As per the joint report of the Orissa Remote Sensing Application Centre (ORSAC), Bhubaneswar and the Hirakud Research (HRC), Hirakud, the reduction of the dead, live and total storage of the reservoir upto 1985 — after 29 years of existence — are 36.7, 14 and 20.4% respectively [33].

The reason for the rapid decrease of the storage capacity of the reservoir is that the actual rate of silt load into the reservoir and its retention is much higher than envisaged in the project reports The different reports before the completion of the Hirakud dam anticipated the following silt load and silt trap.

Table 13

Silt Load and Silt Trap in Hirakud Reservoir Estimated Before Completion [33]

Report	Silt Load into Reservoir in ham/100 km^2 /yr	Silt Trap in ham/ 100 km^2 /yr	Trap Percent
Hirakud Valley Development, 1947	3.570	1 785	50
Report of Advisory Committee, 1948	6 282	3,141	50
Report of Hirakud Dam Project Revised, 1953	4.373	4.500	51.1

The actual observed silt loads into the reservoir, as per the reports of the two hydrographic surveys completed in 1979 and 1982, are 6.6 and 6 82 ham/100 km^2 /yr respectively. Further actual measurement showed that about 75.5% of the silt inflow into the reservoir is actually deposited [33].

These findings are no doubt disturbing and at the rate of the silting given in the report, ***about 70.2% of the total storage of the reservoir will be silted after 100 years of existence of the dam*** (by 2056 AD). Such futuristic extrapolations are, however, subject to a degree of uncertainity and errors but can be considered as indicative.

It is also true that, in very recent years, the rate of silting in the reservoir has shown some decrease, mainly due to construction of a few high and medium dams and many small check dams on the tributaries of Mahanadi (Fig. 4) and partly due to some other soil conservation measures taken in the catchment area. Most of the check dams on the tributaries are very small ones They are not likely to last more than a decade or two. Thus, the recent decreasing trend of silting in the reservoir will probably not help substantially to lengthen the already decreased life of the Hirakud reservoir.

Dam Safety. Safety is a very important factor for consideration in an engineering design. It is more so in the case of large dams If a large dam gives way, the result will be catastrophic in the downstream areas. Despite routine safety precautions taken in the designs, accidents have occurred.

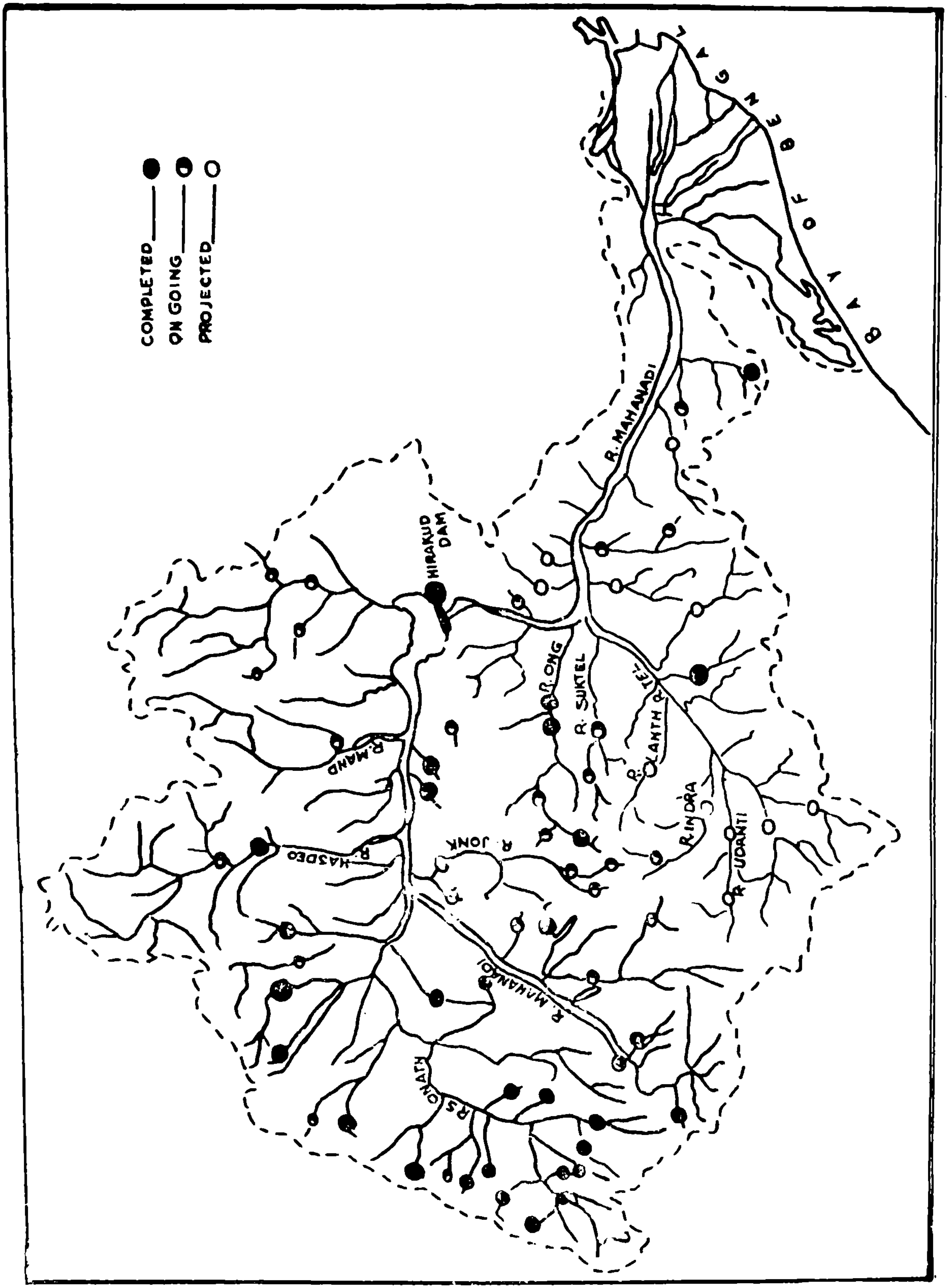


Fig 4 Various Dams Constructed or Projected in the Catchment Area of Mahanadi.

The Most infamous case of dam accident in the country is the earthquake which struck Koynanagar on December 10, 1967. Nearly 200 lives were lost and about 1500 persons were injured. What was most surprising was that Koynanagar is not situated in the seismic zone. While Koyna accident was due to earthquake— probably induced by the large mass of water in the reservoir — another major accident occurred on the Machu Dam in Gujarat in 1979, essentially due to faulty design. The collapse of the dam resulted in flood and death of several hundreds of people in the downstream of Morvi.

Small dam accidents have occurred in Orissa. The following are a few examples [*29*].

River Ghodsal — a tributary of Bansadhara — was dammed at Pratapur for minor irrigation. The dam burst in 1979 and 1981 causing flash floods in Gunupur subdivision. A dam was completed in 1978 on Tenar river — a tributary of Ranial — in Kamakshyanagar subdivision of Dhenkanal district. The dam gave way in 1983 causing flash flood. An accident was reported in the Hadagad dam near Bhadrak town in Balasore district due to broken rails of the sluice gates. All these accidents may be attributed to either faults in construction or improper operation and maintenance.

The large cracks developed in the concrete spillway of the Hirakud dam have generated maximum concern and controversy in the state and outside The government proposes to spend a sum of about rupees 8 2 crores approximately for its repair by sealing with epoxy resins.

Many theories have been proposed for the cause of the cracks. The officially accepted version is that it has happened due to what is called the "alkali aggregate reaction" [*34*]. Certain types of silica aggregates slowly react with the alkali of the cement in the presence of water to form "gels", in which process, swelling takes place and strain develops in the structure. This is the essential principle of the alkali-aggregate reaction (AAR). According to the protagonists of the AAR theory, the right side of the spillway was probably constructed in a hurry without giving sufficient setting time for the cement used As a result, fine cracks developed initally and water speed in. Since the cement used was alkaline, the water set in the slow alkali aggregate reaction. If this theory is correct, the cracks should stabilise by now, because rates of all chemical reactions asymptotically approach zero after certain time. Unfortunately all engineers are not wholly convinced with the AAR hypothesis. Defect in the foundation due to inadequate study cannot possibly be comletely ruled out.•

It is not important at this stage to know what exactly caused the cracks, except for academic interest. The fact is that cracks have actually developed due to human ignorance or failure, irrespective of whether the cause is AAR or foundation defect or any other factor. The public concern, and even scepticism, are legitimate in this situation, not withstanding the assurance given by the persons in charge.

There are many instances of reservoir induced seismology (RIS), that is, earthquake tremors artificially caused by large mass of water in reservoirs. About 80 well-known cases of RIS all over the world have been recorded, e g , Lake Mead in Hoover Dam (USA), Koyna (India), Kremesta (Greece), Kariba (Zambia), Hsinfengkian (China) and Nurek (USSR). Several factors like the amount and rate of reservoir fill, general seismicity and geotectonic set-up in the area surrounding the reservoir etc. influence

---

• The author cannot substantiate this with any printed report. He has gained this knowledge through informal discussions with some engineers who have intimate knowledge of the construction of the Htrakud dam. Thus this opinion can be a subjective one.

the RIS. The exact time of incidence of RIS after reservoir impoundment is variable. Koyna reservoir filling started in 1962, but earthquakes appeared in 1967, 1973 and 1980; the first quake was the most disastrous one. The first earthquake near the Hsinfengkian dam in China occurred three years after the first impoundment of water. RIS occurred soon after the filling in Kremesta and Marathon dams in Greece. Underground mining activity has also been taken as a possible cause of earthquakes. Rock bursts, bumps, outbursts following mining operations may cause earthquakes which can assume damaging proportions. The ambient tectonic set up is important in its reaction to artificial stress field created by reservoir impounding or mining activities to give rise to seismogenic movements [*35*].

In January, 1986 a series of earthquake shocks affected parts of Bramhani valley, specially, around Talcher and Parjanga and to a lesser extent, in Rengali and Deogarh area. There were minor damages to buildings and hutments. It created a big scare among the people. A normal earthquake is not likely in the area considering the seismic zone to which the Bramhani valley belongs. The earthquake could have been a result of artificial causes. The Rengali dam was filling its reservoir for the first time. The mass of water collected behind the dam could have brought in imbalances in the geotectonical set-up of the area leading to shocks. The area lies along the contact of the older Archean rocks and the much younger coal bearing sedimentaries; this is the cause of the weak tectonic set up. The active underground mining activities in the Talcher coal belt — very close to the dam — might have also caused the earthquake [*35*]. It is difficult to pin point the exact cause of the earthquake in Talcher area. Its timing, coinciding with the first impoundment of water in the Rengali dam, could be just accidental. Nevertheless, it will be unwise not to take a serious note of the incidence, particularly when larger mining activities are proposed in the area. Reservoir induced seismology is known to recur sometimes Establishment of a network of seismographs and data monitoring may be helpful for earthquake predictions.

Conclusion No doubt impounding of water is essential for maximum utilisation of water resources. yet while going in for large reservoirs one has to follow the age old maxim : "look before you leap", because big dams necessarily mean big problems to take care of. No aspect — good or bad, small or large — should be neglected. The foregoing discussions also clearly indicate that construction of small dams is not necessarily a small job and one cannot be negligent even for small projects.

WATER POLLUTION—THE INCREASING MENACE

Of late, there has been growing concern in our country and abroad over pollution effects of sewages and trade effluents discharged from human habitations and industrial establishments. The wastewater without proper tereatment, when discharged into a stream or lake, pollutes the water there When discharged on land, the land is also affected if the wastewater has characteristics harmful for soil. Further, it will percolate and contaminate the groundwater if the groundwater table is high and during percolation, the wastewater is not effectively filtered and "cleaned" by the soil There are also evidences that the marine water has started experiencing pollution.

Consequences of Water Pollution. Water pollution affects in two ways: (i) toxic chemicals and harmful microbes in wastewater are health hazards and (ii) nature's response to pollution by aerobic digestion of the pollutants causes decrease in the oxygen concentration in water which is deterimental to aquatic life and may ultimately lead to eutrophication of the water body if the oxygen depletion is serious.

Water pollutants are of two types, viz, those which are easily biodegraded and those which are not. The former category of pollutants, when discharged into a water body, are attacked by aerobic (oxygen demanding) bacteria present there with the help of dissolved oxygen. Consequently, decrease of the concentration of dissolved oxygen takes place. When the oxygen level is very seriously depleted, anaerobic bacteria take over and pollutants are degraded in the absence of air. Aquatic plants and animals also die due to want of oxygen Anaerobic digestion produces methane gas and alongwith it malodorous sulphur compounds. The resultant total absence of oxygen and sludge produced in the digestion process causes the ultimate death of the water body which is called ***"eutrophication"***. ***All inland water bodies do undergo slow eutrophication in the natural process, but this is accelerated if large loads of organic pollutants and nutrients enter the watar body.*** The non-degradable pollutants in water like heavy metals, pesticide residues etc. enter into the food chain through planktons to fishes and so on. In this process, the concentration of a pollutant in the tissues of organisms increases. This process is called "biomagnification". Organisms higher in the food chain bioaccumulate more. Man, being at the top of the food chain, accumulates such pollutants the most.

The picture of water pollution in India is really grim. According to the estimate of scientists of the National Environmental Engineering Institute, Nagpur, ***about 70% of available water in India is polluted and about 73 million workdays are lost per year due to water-related diseasea*** [*36*].

Sources of Water Pollution There are broadly three sources of water pollution. They are the domestic, industrial and nonpoint sources. Wastewater from domestic source (municipal sewage etc.) generally contains many organic and faecal matters alongwith disease-carrying coliforms. They are mostly biodegradable but some organic substances like linear alkyl sulphonates (present in detergents) are not so. The industrial wastewater is likely to contain various types of pollutants depending upon the industrial process. Some of them are toxic and not easily biodegradable. Highly water polluting industries have been listed by the Ministry of Forests and Envirnment, Government of India for the purpose of EIA (Environmental Impact Assessment) clearance for their establishment. The nonpoint sources of pollution consists of run-offs from agricultural fields etc. containing large quantities of chemical fertilisers, pesticides and faecal matters.

A survey of the tndustrial cities in India, made a few years back, shows that industrial wastewater in India constitutes, by volume, between 8 to 16% of the total wastewater generated. The remaining 84-92% come from the domestic sector or from nonpoint sources The figures may reach about 33% and 67% respectively by the end of the century due to rapid rate of industrialisation. In terms of Biochemical Oxygen Demand (BOD) — a very important parameter for assessment of water quality — the pollution load is about 50% each for industrial and domestic wastewater at present [*37*]. Considering the present status of industrialisation of the state, the above figures are expected to be more or less of the same order for Orissa.

The nonpoint sources of pollution are difficult to control. On account of the relatively lower use of agricultural chemicals, the pollution load from nonpoint sources in the state and the country is expected to be less than that in more advanced countries. While the chemical fertiliser used in India is of the order of 16 kg/ha, the world average is about 54 54 kg/ha [*38*].

Classification and Quality Considerations of Water. The assessment of water from any water body for i's quality depends upon the purpose

for which the water is used or recommended for use. Quality considerations will be different for different uses of water.

The Central Board for Prevention and Control of Water Pollution has classified waters of the major rivers of India on the basis of their designated best use [*39*] The various classifications are given in Table 14.

Table 14

Classification of Water on Designated Best Use

Class	Designated Best Use	Required Parameters
Surface Water		
A	Drinking water source without conventional treatment but after disinfection.	(i) Total coliform organisms MPN/100 ml shall be 50 or less. (ii) pH between 6.5 to 8.5 (iii) Diss O_2 : 6 mg/l or more (iv) BOD_5^{20} : 2 mg/l or less (v) Note : There shall be no visible discharge of domestic or industrial wastes.
B	Outdoor bathing, swimming and water contact sports	(i) Total coliform organisms MPN/100 ml shall be 50 or less. (ii) pH between 6.5 to 8.5 (iii) Diss. O_2 : 5 mg/l or more (iv) BOD_5^{20} : 3 mg/l or less (v) Note : All domestic and industrial wastewater discharges upstream of bathing places shall be so regulated that the stream standards are maintained and that there is no visible floating matter including oils at the bathing places.
C	Drinking water source with conventional treatment followed by disinfection	(i) Total coliform organism MPN/100 ml shall be 5000 or less (ii) pH between 6 to 9 (iii) Diss. O_2 : 4 mg/l or more (iv) BOD_5^{20} : 3 mg/l or less (v) Note : All domestic and industrial wastewater discharged into class C water shall necessarily be treated to ensure maintenance of stream standards and the discharge points shall be kept sufficiently away from the abstraction point.

Class	Designated Best Use	Required Parameters
D	Propagation of wildlife and fisheries	(i) PH betwen 6.5 to 8.5
		(ii) Diss.0_2 : 4 mg/l or more
		(iii) Free ammonia (as N) : 1.2 mg/l or less
E	Irrigation, Industrial cooling and controlled waste disposal	(i) PH between 6 0 to 8.5
		(ii) Electrical conductivity at 25°C : Max 2250 mho/cm
		(iii) Sodium absorption ratio : Max 26
		(iv) Boron : Max 2 mg/l

Saline Water

SW I	Salt pan, seal fishing, contact water sports	—
SW II	Commercial fishing, recreation (not contact)	—
SW III	Industrial cooling	—
SW IV	Harbour	—
SW V	Navigation, controlled waste disposal	—

The U. S. Environmental Protection Agency has published criteria for water quality accurately reflecting at the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare which may be expected from the presence of pollutants in any body of water [*41*]. The quality criteria specify concentration limits of water constituents within which an aquatic ecosystem suitable for higher uses of water results.

"Criterion" represents a constituent concentration or level associated with a degree of environmental effect upon which scientific judgement may be based. In the context of aquatic environment, it means a designated concentration of a constituent that when not exceeded will protect an organism or community with an adequate degree of safety. Table 15 describes the quality criteria of water for some selected parameters.

Table 15

Quality Criteria for some Selected Parameters [40, 41]

Parameter	Criteria
Alkalinity	20 mg, l or more as calcium carbonate for fresh water aquatic life except where natural concentrations are less. Maximum levels upto 400 mg/l as calcium carbonate are not considered as a problem to human health. Must not exceed 600 mg/l before adverse effects on plants are noticed.
Faecal coliform	For bathing water, not more than 10% of the total samples taken during any 30 day period should not have faecal coliform bacteria more than 400 MPN per 100 ml.
Hardness	Hardness concentration in water (expressed as mg/l of calcium carbonate) have not proven health related, the final level achieved principally is a function of economics. Since hardness in water can be removed by appropriate treatmennt, a criterion for raw waters used for public water supply is not practical. There are, of course, maximum hardness levels accepted by industries in a raw water source,
Nitrites, Nitrates	10 mg/l nitrate nitrogen(N) for domestic water supply for health
Dissolved Oxygen	A minimum concentration of 5.0 mg/l to maintain good fish population saturation value 7.6 mg/l at 30°C.
PH	5.0—9.0 for domestic water supplies 6.5—9.0 for fresh water aquatic life 6.5—8.5 for marine aquatic life
Dissolved solids and Salinity	250 mg/l for chlorides and sulphates in domestic water supplies. There are maximum total dissolved solid concentrations accepted by different industries for use as raw water.

Various regulating agencies have laid down different standards for water quality. The word "standard" is not synonymous with "criterion". It connotes a legal entity. A standard may differ from a criterion because of prevailing local natural conditions, such as naturally occurring acids, or because of the importance of a particular water body, economic considerations, or the degree of safety desired for a particular ecosystem. Standards for drinking water have been laid down by the world Health Organisation (WHO) and by the Ministry of Works and Housing (Table 16). Standards for the tolerance limits for inland surface waters subject to pollution have been laid by the Bureau of Indian Standards (IS 2296-1982). The classification of water to Class B and Class C in Table 14 is based on the above standard. Standards have also been laid down by the Central and the State Pollution Control Boards and by the Bureau of Indian Standards for Industrial effluents and municipal sewages discharged into various types of water bodies.

Table 16

Drinking Water Standards [*37*]

Characteristics/ Water Source	**World Health Organisation (1971)**		**Ministry of Works and Housing (1975)**	
	Highest desirable	**Maximum permissible**	**Acceptable**	**Cause of rejection**
Chemical characteristics				
pH	7.0 — 8.5	6.5 — 9.2	7.0 — 8.5	6.5 — 9.2
Total solids (mg/l)	500	1500	500	1500
Total hardness (mg/l) (as $CaCO_3$)	100	500	200	600
Magnesium (mg/l)	30	150	30	150
Chloride (mg/l)	200	600	200	1000
Sulphate (mg/l) (as SO_4)	200	400	200	400
Nitrade (mg/l) (as NO_3)	45	45	45	45

Bacteriological

Water Source	**World Health Organisation (1971)**	**Ministry of works and Housing (1975)**
Water entering distribution system	If disinfected coliform count in any sample of 100 ml should be zero.	Coliform count in any sample of 100 ml should be zero.
Water in distribution system	Ideally all samples taken from the distribution system including consumers' premises should be free from coliform organisms. Since. in practice it is not always possible, hence the following standards :	Water in the distribution system shall satisfy all the three criteria indicated below.
	(i) throughout any year 95% of the samples examined should not have any coliform organism·	(i) E. Coli count in 100 ml of any sample should be zero.
	ii) E. Coli count in 100 ml of any sample should be zero.	ii) Coliform organisms not more than 10 per 100 ml shall be present in any sample.
	(iii) Coliform organisms not more than 10 per 100 ml shall be present in any sample.	(iii) Coliform organisms should not be detectable in 100ml of any two consecutive samples or more than 50% of the samples collected for the year.
	iv) Coliform organisms should not be detectable in 100 ml of any two consecutive samples	

It is evident from the foregoing discussion that while assesing the overall water quality of any water body one must consider (i) the purpose for which the water is used or intended to be used (classification according to Central Pollution Control Board as in Table 14), (ii) legal requirements (standards of regulating agencies as in Table 16) and (iii) scientific consideration of environmental effects (quality criteria as in Table 15).

Water Quality of Bramhani Rever. Bramhani is the second largest river of Orissa—next only to Mahandi. Most of the major industries of the state discharge their wastewaters into it, viz, Rourkela Steel and Fertiliser Plants (Rourkela), Talcher Thermal Power Station (Talcher), Fertiliser Corporation of India (Talcher), Heavy Water Project (Talcher), National Aluminium Company Smelter and Captive Power Plants (Angul), ORICHEM Ltd. (Talcher), South Eastern Coalfields (Talcher), Orissa Synthetics Ltd. (Dhenkanal). Altogether these industries dischage more than 1.2 lakh m^3 of effluent per day. Besides sewage water of the steel plant and civil townships at Rourkela enter into Bramhani river. The river in the lower reaches passes through very populated areas from where domestic pollution load into the river is expected to be high Thus, Bramhani river is subject to heavy stress of pollution.

The water of Bramhani has been classified by the Central Board for Prevention & Control of Water Pollution as Class "C" water from its origin to the point of emergence of distributaries in the coastal plains which means that, in this stretch, the water should be suitable as the source of drinking water supply with conventional treatment followed by disinfection (not directly potable). From the emergence of the distributaries to the saline tidal limit, the water is classified as Class 'B' water that is suitable for outdoor bathing. Further down upto the Bay of Bengal, the water is classified as SW II class (commercial fishing and recreation-non contact).

The Orissa State Prevention & Control of Pollution Board has been monitoring the water quality of Bramhani river in monthly intervals for last three years. Table 17 shows the values for a limited number of parameters.

TABLE 17

Water Quality of River Bramhani (April, 1985—March, 1988)

(The upper and lower figures indicate respectively the lowest and the highest values)

Parameters / **Stations**	**DO** mg/1	**BOD$_5^{20}$** mg/1	**TDS** mg/1	**pH**	**Total Hardness** mg/1	**Total coliform MPN/ 100 ml**	**Fecal coliform MPN/ 100 ml**
Panposh	5.2	1.8	54.2	6.5	32	93	3
(upstream)	8.7	9.0	248	8.0	102	$\geq$2400	1100
Panposh	4.8	4.0	131	6.4	48	210	3
(downstream)	7.2	24.5	311	8.5	158	$\geq$2400	1100
Bonaigarh	4.8	2.8	86.5	6.8	32	210	7
	8.2	18	254	8.2	96	$\geq$2400	1100
Rengali	4.0	2.0	44.2	6.8	32	9.0	$<$3
	8.1	11.3	251	8.2	102	1100	460
Samal	4.0	1.8	62	6.8	43	75	$<$3
	8.5	12.5	250	8.1	116	$\geq$2400	1100
Kamalanga	3.8	3.5	52	7.4	70	210	$<$3
	7.6	13	256	9.4	104	$\geq$2400	460
Bhuban	5.0	4.0	52	7.0	32	460	$<$3
	8.0	10	306	9.0	129	$\geq$2400	460
Dharmasala	5.0	3.6	52	7.1	72	150	$<$3
	8.0	9.5	332	8.5	116	$\geq$2400	1100
Pattamundai	5.6	2.4	52	6.5	76	93	$<$3
	8.6	9.6	270	8.5	160	$\geq$2400	210

DO—Dissolved Oxygen, BOD$_5^{20}$—Biochemical Oxygen Demand (5 days, 20°C)

TDS—Total Dissolved Solids

Comparison of analysis data of Bramhani water with the water quality criteria and the different standards shows that the water is not suitable for use as potable water. It is also not classified as a source of direct drinking water without any kind of treatment or disinfection. Further, the stretch of river which has been classified as "C" (source of drinking water supply with conventional treatment and disinfection) has ceased to be so with regard to BOD and at stretches, during certain parts of the year, with regard to pH A sharp deterioration of water quality takes place at the downstream of Panposh evidently due to the industrial complex at Rourkela and the townships Deterioration of water quality near Kamalanga is obviously mainly due to the industrial complex in the Angul-Talcher area An interesting feature is that, in spite of the fairly high pollution load, depletion of dissolved oxygen concentration below the desired level required for the support of fish population (4mg/l) does not take place except at Kamalanga during summer and early monsoon. This may be indicative of good self regenerating capacity of the water. At most places, the maximum level of total coliform bacteria exceeds 2400 MPN/100ml which is bad enough for most purposes.

In the overall sense, ***the Bramhani water stream, as it stands to day. does not represent a healthy aquatic ecosystem.*** This picture of Bramhani is similar to most water streams in India. Many rivers like Ganga and Damodar are in a much worse condition.

Water Quality of Mahanadi and Baitarani Rivers. A study of the water qulity of Mahanadi river, particularly in the upper reaches, was made by the University College of Engineering and the School of Life Sciences at Burla between 1983 to 1985 with the support of the Department of Environment, Government of India *[42]*. The State Board for the Prevention & Control of Pollution has also started monitoring the water since a few months back, but the study is incomplete. The results, only with respect to a few parameters, are given in Table 18.

The conclusions drawn with respect to Mahanadi water is similar to those for Bramhani river. The Mahanadi water is not directly potable, except in the middle stretches near Kiakata where the population density is less. It also does not conform to Class 'C' character, at many places (e. g., downstream of Sambalpur Cuttack and Choudwar). The pollution load on Mahanadi is mainly from municipal and other domestic wastewaters except at Choudwar. The pollution of river Ib—a tributary of Mahanadi is, of course, mostly due to a paper mill. This is discussed separately.

The State Board has also started monitoring of Baitarani water on a seasonal basis. Preliminary information shows the water quality to be similar to Mahanadi Here the pollution can be directly attributed mainly to domestic and non-point sources.

Table 18

Water Quality of River Mahanadi (March, 1988 – August. 1988)

(The upper and the lower figures indicate respectively the lowest and the highest values)

Parameters / Stations	DO mg/1	BOD_5^{20} mg/1	TDS mg/1	pH	Total Hardness mg 1	Total coliform MPN/ 100 ml	Fecal coliform MPN/ 100 ml
Ib (at Brajaraj Nagar)	6.0	2.3	70	7.3	40	1100	93
	8.8	4.0	150	7.63	100	$\geq$2400	240
Ib (down stream of	4 0	26.0	130	7.10	60	1100	120
Brajaraj Nagar)	6.2	36 0	240	8.05	205	$\geq$2400	240
Ib (at Jharsuguda)	6.2	4.0	90	7.2	60	1100	120
	8.2	5.6	130	8.1	100	$\geq$2400	210
Ib (at Sundergarh)	6.0	3.2	90	7.5	54	1100	210
	8.0	6 0	290	7.8	75	$\geq$2400	240
Hirakud Reservoir	6.1	2.0	180	7.9	72	39	14
	7.2	4 0	230	8.6	110	46	21
Sambalpur	7.0	3.0	100	7.2	76	1100	150
(Upstream)	7.4	8 0	160	8.1	110	$\geq$2400	1100
Sambalpur	6.2	5.0	110	7.2	80	2400	1100
(Downstream)	7.3	8.0	170	7.9	128	$\geq$2400	
Sonepur (at confluence	4.7	0.4	110	7.2	72	150	21
of Ong river	8.2	7.6	160	8.1	140	1100	240
Sonepur (at confluence	4.4	0.8	90	6.6	86	960	150
of Tel river	8.2	6.0	200	8.3	110	$\geq$2400	460
Cuttack (upstream)	5 6	4,0	120	8.2	90	1100	210
	6.4	4.8	180	8.7	100	$\geq$2400	240
Cuttack (downstream)	5.0	4 0	130	7.9	90	$\geq$2400	210
	6.2	5 0	190	8.0	110	$\geq$2400	240
Bhargavi (at intake point	5.2	3.8	90	7.3	50	1100	150
of Bhubaneswar	6.4	6.0	220	7.6	100	$\geq$2400	290

DO – Dissolved Oxygen, BOD_5^{20} – Baiochemical Oxygen Demand (5 days, 20°C)

TDS – Total Dissolved Solids

Pollution of Othei Small Rivers and Streams. River Ib which is a tributary of Mahanadi falls into the Hirakud reservoir. On its bank is situated Orissa's largest paper mill, the Orient Paper Mill at Brajarajnagar. The effluent of the mill which is not adequately treated, is discharged into it causing a serious pollution problem which has been thoroughly studied by the Sambalpur University team already mentioned. The problem is aggravated by the fact that river Ib has very little flow in the dry summer months and the paper mill effluent, however treated, cannot get sufficienfly diluted to protect the stream. An exactly similar situation exists with the river Nagavali whose water flow is much less than the river lb. On its bank, is situated another paper mill—M/s Straw Products Ltd., (which has a full-fledged treatmsnt plant for its wastewater). The problem of pollution of rivers Ib and Nagavali cannot be solved unless effluents of the paper mills are totally diverted for irrigation purposes after necessary treatment The utility of wastewater for irrigation has already been described.

Nandira is another rivulet in Talcher area which receives heavy pollution load from the untreated or inadequately treated effluents mainly from the nearby thermal power plant and the fertiliser plant. The Guradi nulla at Rourkela is a natural drain carrying the effluent of the steel mill and the sewage of the township. In the very design, the nullah has been sacrified to the plant. Both Nandira rivulet and the Guradi Nulla discharge into Bramhani river and contribute towards the pollution of the latter.

Another small drain which gets severely polluted because of the very high BOD—containing sugar mill and distillery effluent, is the Kaifullia nulla near Aska town in Ganjam district. This stream ultimately gets discharged into river Rusikulya. However, the most hazardous pollution of Rusikulya is due to the chlor alkali factory at Ganjam (M/s. Jayshree Chemicals Ltd.) which discharges its mercury bearing effluent into the river. This has created a great deal of resentment in the past Mercury is regarded as a highly hazardous substance

The problems of industrial pollution will be discussed in greater detail in a separate volume of the State of Environment Report. It may only be mentioned here there that, excepting a few, most of the industrial units mentioned above are in the process of installation or upgradation of their effluent treatment plants (ETP's) In any case, very small streams carrying industrial effluents cannot be protected from pollution by the ETP's because they simply do not carry sufficient water to cause adequate dilution of the treated effluents, particularly in the dry months.

Pollution of Groundwtter Generally, the groundwater found in consolidate and semi-consolidate formation is suitable for most purposes including drinking. But it is found in some areas of Mayurbhanj, Keonjhar and Sundergarh districts that the iron content in groundwater is very high. so much so that, at places, it is as high as 34 mg/l against the recommended standard of 0 3 mg/l. The general quality parameters for groundwater are : total hardness, 25-205 mg/l; bicarbonate, 5-270 mg/l; chloride, 14-75 mg/l; specific conductivity, 97-762 micromho/cm; sodium, 4-42 mg/l and potassium, 2-14 mg l. Water in shallow aquifers in deltaic and coastal areas have dissolved solids, hardness, bicarbona'es and chlorides in the ranges of 265-1034, 21-263, 5-468, 14-307 mg/l respectively [*2*].

Saline intrusion may result when there is a decline of water table in coastal areas due to overuse. According to Shri J. Tripathy, Retired Chief Engineer of Orissa, drainage of two swampy lakes near Puri town ("Sur" and "Samanga" lakes) to the sea might result in saline encroachment into the groundwater of Puri [*18*], because these lakes used to charge the

groundwater there. This is of course, a conjecture. Groundwater with high water table can get polluted by leachings containing various pollutants like fertilisers and pesticides used in agricultural fields, organic matter from abandoned pits, wastes of industries containing toxic substances stored in unlined pits etc. Unfortunately no systematic study of groundwater pollution has been done in the state. Such a study is overdue. With a large aluminium smelter and a large phosphatic fertiliser plant established at Angul and Paradeep respectively, it is necessary to be watchful of fluoride contamination of groundwater (as well as surface water) in those areas. Already fluoride pollution of shallow groundwater in a limited area in Hirakud has been reported - caused by the haphazard disposal of rejected pot linings of an aluminium plant in the past. With many industries in Orissa using chromite ore, it is also necessary to keep a watch on groundwater and surface water contamInation by hexavalent chromium which is a known toxic substance,

Conclusion Water pollution in Orissa is mainly confined to surface water. An overall pollution picture is that, although industries contribute towards water pollution and it is fairly serious at some places, the main bulk of pollution load is due to domest c wastes and from non-point sources. None of the municipalities and NAC's has any sewage treatment plant (STP) and only two of them; viz, the steel township at Rourkela and the industrial township of Sunabeda, have regular sewerage systems. While almost all the industrial units without ETP's have taken up or propose to take up soon the work of installation of treatment plants for their wastewaters, the urban local bodies do not have any prospective planning for construction of sewerage system with treatment plants in near future.

In this respect, the largest municipality at Cuttack may perhaps be one of the greatest water polluting human settlements in the state. A so-called storm water drain was constructed at Cuttabk a few years back for quick discharge of rain water to Kathjuri river. The problem of water discharge at Cuttack after a shower or two is really serious, because of the unplanned growth of the city whereby low-lying areas have been encroached for habitation — a classic case of environmental mismanagement. A storm water drain is normally expected to be dry for most of the time except during heavy rains. Its water is not supposed to be polluting because of large dilution caused during rains. The so-called storm water drain at Cuttack is however always full and the water in it is no better than sewage water. It is a source of health hazard for the city. The leaking sluice gate at the point of discharge to Kathjuri causes wafer pollution of the river; this is .particularly serious because the source of domestic water supply to a part of the city (industrial estate at Madhupatna) is close to the discharge point in the downstream direction.

The situation is no better at the national level. The following reproduction of a statement by Dr. T N. Khusoo, the former Secretary to the Government of India in the Ministry of Environment, clearly vindicates the point of view expressed in this report

> "Obviously it is clear ...., firstly, that by volume sewerage is the major cause of water pollution and that the tasks involved in setting right the situation are indeed enormous. Secondly as long as cities remain unsewered and facilities for collection, treatment and disposal of liquid and solid wastes are nonexistent resulting in continued pollution of our water systems, efforts on the part of individual polluter will have limited effect although may satisfy statutory obligation. Thirdly, the pollution potential of Class-II towns vis a vis Class-I is about 1:6 in terms of wastewater generation, while in terms of population, it is about 1:5. Fourthly, there is a chronic scarcity of funds in the civic bodies and sewarage and sewage treatment is given a very low order of priority by the state and the central Governments" [*43*].

In the beginning of our developmental activities, there was practically no culture of pollution control in the country resulting in heavy backlog of pollution. While more than 50% of the backlog of major and medium industries in the country have installed pollution control equipments in the last few years since the creation of the different Pollution Control Boards (44), which is not a small achievement for a third world country, those Boards and their respective Departments of Environment in the Governments have almost totally failed to discipline the urban local bodies. Unless they are disciplined to instal sewarage systems and sewage treatment plants, attainment of pollution free water will remain a distant cry. Simultaneously, the existing pressures on recalcitrant industrial units imbued with only the profit motive without any social obligation towards pollution control should not be relaxed. A clear commitment to cleaner environment at the bureaucratic and political levels is necessary.

SUMMING UP

Finally, it may be added that whatever has been said in the above discourse, by the way of interpreting the available facts and statistics, is by no means intended to detract from the excellent work done in several fields of water management by our planners, scientists, engineers and workers. Nevertheless it has to be brought out the dangers of an euphoria over the big and the beautiful and the superior virtues of a balanced attitude that takes care of the traditional, the socio-cultural and the environmental needs of the society in a long term perspective. The quality of life is an indivisible whole and it does not have to be eroded by the "benefits" of water in any of its segments, if we can help it. And, talking of benefits, while it is important to set the process in motion, and in due time, it is more important to monitor the end-results carefully and over a period of time so that benefits do indeed accrue to the poorest beneficiary in the farthest corners of the grand design, and the initial effulgence is not lost—even if unknowingly—in the widening shadows of apathy and neglect.

Furthermore, if lessons have to be learnt, let us keep in mind that the act of working out the cost benefit ratio is not merely a financial exercise; it has necessarily to cover the social costs and benefits, the tangibles as well as the intangibles, if we do claim to have a genuine regard for the aforesaid godhead of our values—the quality of life. In this, we would do well to follow the lead of the developed countries, and not to be discouraged by the apparently tedious process of moving beyond the visible impacts into the elusive incidences, implications and what have you, nor by the mere fact that much of it cannot be quantified in monetary terms. And let the decision be taken only when all the facts, fears and possibilities are analysed by the policy-maker and he can then make a wise and farsighted choice between the pros and cons. Success is not a spectacle of to-day, but a blessing that abides for all our tomorrows.

REFERENCES

1. M. I. Lovich, "*The World's Waters*", Mir Publishers, Moscow, 1973, p 18.

2. S. Das, "*Status of Groundwater in Orissa*", Paper presented at the **Symposium on Environmental Aspects of Water Resources of Orissa** held at Bhubaneswar July 30, 1988.

3. Data collected from Water and Land Management Institute (WALMI), Bhubaneswar—personal communication.

4. D. Mishra, Introductory Address at the Seminar on "*Perspective Planning of Water Resources of Orissa*" held at Bhubaneswar, May 5, 1988.

5. G. Mahapatra, N. C. Pandey and K. N. Chari, "*Catchment Characteristics of the River System of Orissa*", Report of the Soil Conservation Department, Government of Orissa.

6. A. B Jena, "*Development of Water Resources in Orissa and Associated Problems*" **Proc. of the Symposium on Environmental Aspects of Water Resources of Orissa** held at Bhubaneswar, July 30, 1988, p 2.1

7. Sixth Plan Document, Government of India, New Delhi.

8. Orissa Agricultural Statistics, 1985-86. Directorate of Agriculture, Bhubaneswar.

9. K. C. Das, '*Extent of Irrigation and its Environmental Impacts in Orissa*", **Proc. of the Symposium on Environmental Aspects of Water Resources of Orissa** held at Bhubaneswar, July 30, 1988 p 9.1

10. B. B. Vohra, "*Grave Neglect*", **Seminar 346,** June 1988, p 15

11. D. Lenka, "*Water Use Efficiency in Rice*" **Proc. of the Development & Management Training Course on Water Management in Rice—based Irrigation Systems,** Human Resources Development Group, WAPCOS, New Delhi, 1987, p 109.

12. "*Water-logging In Orissa*"—Report of Orissa Remote Sensing Application Centre, Bhubaneswar.

13. S. N. Pradhan, "*Exploration and Use of Groundwater Resources of Orissa*", **Proc. of the Symposium on Environmental Aspects of Water Resources of Orissa** held at Bhubaneswar, July 30, 1988 p 7.1

14. B. S. Padmanabhan, "*Groundwater for Irrigation—Delayed Recognition of Role*", **The Hindu Survey of Indian Agriculture,** 1988, p 69.

15. "*The State of India's Environment, 1984-85—The Second Citizen's Report*", The Centre for Science & Environment Publn , 1985, p 33.

16. Same as ref *15* p 39

17. R. C. Das, "*Water—An Unique and Important Substance*", **Proc of the Symposium on Environmental Aspects of Water Resources in Orissa** held at Bhubaneswar July 30, 1988, p 1.1

18. "*Process Design Mannual for Land Treatment of Municipal Wastewater*", US Environmental Protection Agency, 1981.

19. "*Wastewater—Is Muskegon County's Solution Your Solution*", U. S. Environmental Protection Agency, 1979.

20. T. Satpathy, "*Irrigation and Economic Development*", Ashish Publishing House, New Delhi, 1984, p. 179

21. A B. Jena, "*Flood Problems of Orissa*", Souvenir published on the occasion of the Orissa Engineering Congress held at Bhubaneswar in April, 1986, p 41.

22. J. Tripathy, "*Water Resources : Its Development and Use in Orissa*", Lecture delivered on the Water Resource Day, 1987.

23 As reported in the **Times of India**, Aug 22, 1988.

24. S. N. Bhanja Deo, "*Flood Control and Allied Problems of Orissa Rivers Part I*, Government of Orissa Publ., p 3.

25. *"The State of India's Environment, 1982—The Citizen's Report"*, The Centre for Science & Environment Publ , 1982, p 4.

26. Information collected from the Department of Irrigation & Power, Government of Orissa—personal communication.

27. Same as ref *25*, p 68.

28. A. Mishra and M. C. Dash, *"Desertification Around Hirakud Reservoir"*, **The Environmentalist,** 4, 1984, p 51.

29. B. N. Sahu, *"Environmental Effects of Dams in Orissa—Some Case Studies"*, **Proc Symposium on Environmental Aspects of Water Resources of Orissa** held at Bhubaneswar, july 30, 1988, p 6.1

30. B N. Sahu, *"Odisara Nadibandha Jojana O Paribesha"* (in Oriya), Biswakarma Pratisthana Publ. 1987.

31. *"Guidelines for Environmental Assesment of River Valley Projects"*, Ministry of Environment & Forests, Government of India publ , 1985, p 4.

32. *"Sedimentation Studies in Hirakud Reservoir Research Scheme Applied to River Valley Projects"*, "C B I & P"—Final Report, Government of Orissa I & P Department, Hirakud Research Station, Hirakud. 1983.

33. R. B. Mohanty, G. Mohapatra, D. Mishra & S. S. Mohapatra, *"Application of Remote Sensing to Sedimentation Studies in Hirakud Reservoir"*, Published by Orissa Remote Sensing Application Centre, Bhubaneswar and Hirakud Research Station, Hirakud. 1983.

34. Report of the Committee of Experts to Study and Advise Remedial Measures on Cracks in Hirakud Dam Spilway Vol II — for I & P Department, Government of Orissa, 1983.

35. N. K Mahallik (Prof. of Geology, Utkal University, Bhubaneswar—private communication.

36 Same as ref *25*, p 16.

37. N Choudhuri, *"Water and Air Quality Control ; The Indian Context"*, Lecture Delivered at the Tenth Anniversary of the 1972 Stockholm Conference on Human Environment held at New Delhi, 1982.

38. T. N. Khusoo, *"Environmental Priorities in India and Sustainable Development"*, Presidential Address at the 73rd Session of Indian Science Congress held at New Delhi, Jan 3-7, 1986, p 115.

39. River Basin Atlas for India prepared by the Central Board for Prevention & Control of Water Pollution, 1985

40. R. E Train, *"Quality Criteria for Water"*, Castle House Publ., 1979

41. L. N. Patnaik, *"Water Quality of Bramhani and Mahanadi Water Systems"*, **Proc. Symposium on Environmental Aspects of Water Resources in Orissa,** held at Bhubaneswar, July 30, 1988, p 10.1.

42. R. C Das and M. C. Dash, *"Pollution Load and Water Quality of Mahanadi Water System"*, Report Submitted to the Department of Environment, Government of India, 1983.

43. Ref *38* p 116

44. Ref *38*, p 118

ABOUT THE MEMBERS OF THE EDITORIAL BOARD

Dr R. C. Das

Prof. Das did his Ph.D in Physical Chemistry from the Utkal University and also in Radiation Chemistry from the Leeds University in the UK. He has done a considerable amount of research in the field of Environmental Science since last 13 years in both India and Japan. His works on air pollution in urban areas and pollution load in Mahanadi river have been well-recognised. Dr Das has more than 31 years of teaching, research & administrative experience. Presently he is the Chairman of the State Prevention & Control of Pollution Board, Orissa. He has authored the "Water Resources" section of the State of Environment Report.

Dr J. M. Patnaik

Dr Patnaik is a Ph.D degree holder from the School of Environmental Sciences of the Jawaharlal Nehru University. New Delhi. Prior to that he had obtained M. Sc degree in Zoology and post-graduate diploma in Resource Ecology from the Benaras Hindu University. He has more than 26 years of teaching and research experience. He is presently placed in the Department of Science, Technology & Environment of the Government of Orissa as Senior Scientist in charge of Ecology and Environment.

Dr L. N. Patnaik

Dr Patnaik got his Ph.D in Physical Chemistry in 1973. He was also the Gold Medalist of the Utkal University in the year 1965. He has been a college teacher in the Orissa Education Service for the last 22 years. His research interests include theoretical chemistry, spectroscopy and environmental chemistry. Presently he is working as Scientist-C of the SPCP Board, Orissa, heading the scientific section.

Sri A. B. Jena

Shri Jena is a retired Chief Engineer of the Irrigation Department of the Government of Orissa He has been associated with almost all major & medium irrigation projects in Orissa during his career. As Chief Engineer, he was in charge of flood control in the Mahanadi delta, construction of Mahanadi barrage and various medium and minor projects. At present, he is a Consultant to the Government of Orissa for some irrigation projects and also a part-time teacher in the College of Engineering & Technology, OUAT, Bhubaneswar.

Errata

Page 2 column 2 line 4	canstantly read constantly
Page 7 heading of Table 3	Information read Informations
Page 11 column 1 line 6	post-independent read post-independence
Page 12 column 1 line 29	water read Water
Page 13 column 1 line 6	) to be (
Page 17 column 2 line 14	pre independence read pre-independence
Page 19 column 1 line 35	propotion read proportion
Page 20 column 1 line 36	delete (
Page 20 column 2 line 31	Ruikulya read Rusikulya
Page 21 column 1 line 28	put) at the end
Page 21 column 2 line 20	post-independent read post-independence
Page 21 column 2 line 23	i) read (i)
Page 21 column 2 line 24	generatin read generation
Page 23 column 1 Delete line 7	
Page 26 table 10	Information read Informations
Page 30 column 2 line 4	is read are
Page 33 column 2 line 11	speed read seeped
Page 34 column 2 line 8	yet read Yet
Page 35 column 1 line 37	diseasea read diseases
Page 35 column 2 line 39	£4 54 read 54
Page 37 table 14 line 1	PH read pH
Page 37 table 14 line 4	PH read pH
Page 38 table 15 Under parameter PH read pH	
Page 38 column 1 line 11	world read World
Page 38 column 2 line 6	standard read standards
page 40 column 1 line 1	Rever read River
Page 41 headings of Table 17 mg/1 read mg/l	
Page 43 heading of Table 18 mg/1 read mg/l	
Page 43 lines under stations put after lines 12, 14 & 18	
Page 44 column 2 line 17 Groundwtter read Groundwater	
Page 47 item 18 Munlcipal read Muncipal	